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ABSTRACT

One of a series of training manuals prepared for enlisted personnel in the Navy and Naval Reserve, this self-study package provides subject matter that relates directly to the occupational qualifications of the Quartermaster rating. Contents include a 16-chapter text followed by a glossary, subject index, and the associated nonresident career course (11 reading assignments and technical questions based upon each occupational standard in the respective assignment). Chapter headings are (1) The Quartermaster, (2) Quartermaster Watches, (3) Honors and Ceremonies, (4) Magnetic Compass and Gyrocompass, (5) Aids to Navigation, (6) Rules of the Road, (7) Charts and Publications, (8) Time and Timepieces, (9) Introduction to Navigation, (10) Dead Reckoning and Piloting, (11) Electronic Navigation, (12) Celestial Navigation, (13) Tides and Currents, (14) Weather, (15) Maneuvering Board, and (16) Communications. (HD)

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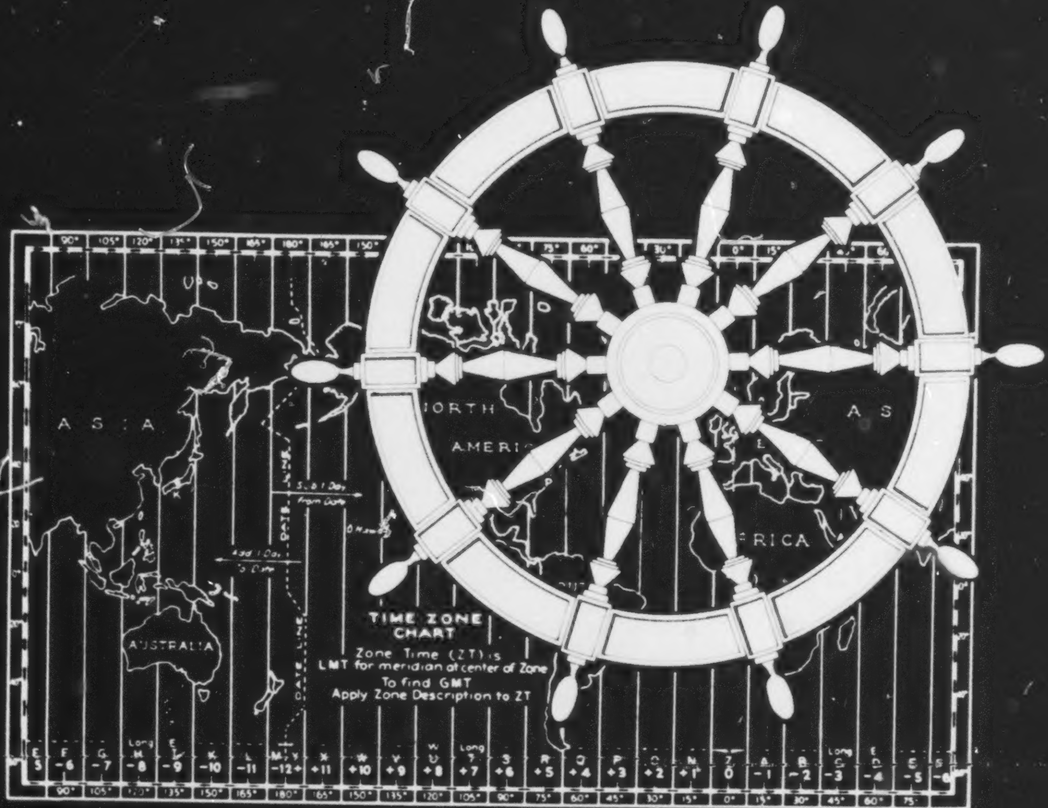
ASIA
NORTH AMERICA
AFRICA
AUSTRALIA
DATE LINE
Sub 1 Day from Date
Add 1 Day to Date
TIME ZONE CHART
Zone Time (ZT) is LMT for meridian at center of Zone
To find GMT Apply Zone Description to ZT

QUARTERMASTER 3 & 2

NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL
AND NONRESIDENT CAREER COURSE

NAVEDTRA 10149-F

CE 008 424

U.S. DEPARTMENT OF HEALTH
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PREFACE

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable ambitious Quartermasters to help themselves fulfill the requirements of their rating. Among these requirements are the abilities to stand watch as assistants to the officer of the deck and to the navigator; serve as steersmen and perform ship control, navigation, and bridge watch duties; procure, correct, use and stow navigational and oceanographic publications and oceanographic charts; maintain navigational instruments and keep correct navigational time; render "honors and ceremonies" in accordance with national observance and foreign customs; send and receive visual messages; and serve as petty officers in charge of tugs, self-propelled barges, and other yard and district craft.

Designed for individual study and not formal classroom instruction, the RTM provides subject matter that relates directly to the occupational qualifications of the Quartermaster rating. The NRCC provides the usual way of satisfying the requirements for completing the RTM. The set of assignments in the NRCC includes learning objectives and supporting items designed to lead students through the RTM.

This training manual and nonresident career course was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical assistance was provided by the Defense Mapping Agency Hydrographic Center; U.S. Naval Observatory; Service School Command (QM School), Orlando, Florida and San Diego, California; and United States Naval Academy.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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CHAPTER 1

THE QUARTERMASTER

This rate training manual has been prepared for men of the Navy and of the Naval Reserve who are studying for advancement to the rates of Quartermaster 3 and Quartermaster 2. The Quartermaster standards used as a guide in the preparation of this rate training manual are contained in the *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards*, NAVPERS 18068–D. Changes occurring after this revision are not reflected in this text.

The remainder of this chapter gives information on the enlisted rating structure, the Quartermaster rating, and references that will help you both in working for advancement and in performing your duties as a Quartermaster, and information on how to make the best use of rate training manuals. Therefore, it is strongly recommended that you study this chapter carefully before beginning intensive study of the remainder of this manual.

ENLISTED RATING STRUCTURE

The two main types of ratings in the present enlisted rating structure are general ratings and service ratings.

GENERAL RATINGS identify broad occupational fields of related duties and functions. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

SERVICE RATINGS identify subdivisions or specialties within a general rating. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

QUARTERMASTER RATING

The Quartermaster rating is a general rating at all petty officer levels. Among the many duties required of a QM are those connected with navigation, steering and ship control, communications, weather, recordkeeping, and supervision of personnel.

Quartermasters are assigned to all combatant ships and to all but the smallest types of auxiliary vessels. Ashore, Quartermasters are assigned to signal stations, weather stations, and small craft units; or they may be assigned to general duties, such as master-at-arms or ceremonial guard.

Aboard ship, a Quartermaster 3 or 2 will stand watches on the bridge as the assistant to the officer of the deck (OOD). To function effectively as his assistant, you must know his duties nearly as well as your own. As QM of the watch, you will spend your duty time in the limelight and, for this reason, you must meet standards of appearance and performance that are more exacting than those of any other department on board.

SPECIAL QUALIFICATION

Figure 1-1 gives a more detailed view of the requirements for advancement of active duty personnel; figure 1-2 gives this information for inactive duty personnel. Remember that the standards for advancement can change. Check with your division officer or training officer to be sure that you know the most recent standards.

REQUIREMENTS *	E1 to E2	E2 to E3	# E3 to E4	#E4 to E5	E5 to E6	† E6 to E7	† E7 to E8	† E8 to E9
SERVICE	4 mos. service- or completion of Recruit Training.	8 mos. as E-2.	6 mos. as E-3. 2 years time in service.	12 mos. as E-4. 3 years time in service.	24 mos. as E-5. 6 years time in service.	36 mos as E-6. 9 years time in service.	36 mos. as E-7. 8 of 12 years time in service must be enlisted.	36 mos. as E-8. 10 of 15 years time in service must be enlisted.
SCHOOL	Recruit Training. (C.O. may advance up to 10% of graduating class.)		Class A for PR3, DT3, IS3, AME 3, HM 3, PN 3, FTB 3, MT 3,			Navy School for AGC, MUC, MNC.††		
PRACTICAL FACTORS	Locally prepared check-offs.	Record of Practical Factors, NavEdTra 1414/1, must be completed for E-3 and all PO advancements.						
PERFORMANCE TEST			Specified ratings must complete applicable performance tests before taking examinations.					
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS **	Locally prepared tests.	See below.	Navy-wide examinations required for all PO advancements.			Navy-wide selection board.		
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)		Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavEdTra 10052 (current edition).					Nonresident career courses and recommended reading. See NavEdTra 10052 (current edition).	
AUTHORIZATION	Commanding Officer		NAVEDTRA PRODEVCEN					

* All advancements require commanding officer's recommendation.

† 3 years obligated service required for E-7, E-8, and E-9.

# Military leadership exam required for E-4 and E-5.

** For E-2 to E-3, NAVEDTRA PRODEVCEN exams or locally prepared tests may be used.

†† Waived for qualified EOD personnel.

Figure 1-1.—Active duty advancement requirements.

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	4 mos.	8 mos.	6 mos.	12 mos.	24 mos.	36 mos. with total 9 yrs service	36 mos. with total 12 yrs service	24 mos. with total 15 yrs service
TOTAL TRAINING DUTY IN GRADE †	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS	▨	▨	Specified ratings must complete applicable performance tests before taking examination.					
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit in accordance with BUPERSINST 5400.42 series.							
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)	Record of Practical Factors, NavEdTra 1414/1, must be completed for all advancements.							
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam		Standard Exam required for all PO advancements. Also pass Military Leadership Exam for E-4 and E-5.				Standard Exam, Selection Board.	
AUTHORIZATION	Commanding Officer		NAVEDTRA·PRODEVCEN					

*Recommendation by commanding officer required for all advancements.
†Active duty periods may be substituted for training duty.

Figure 1-2.—Inactive duty advancement requirements.

Note in figures 1-1 and 1-2 that certain specified ratings must complete applicable performance tests to be eligible for advancement. Quartermaster is one such rating. At the E-4 level, Quartermasters must demonstrate their ability to transmit and receive code groups by flashing light at 6 groups per minute; transmit and receive plain language messages by flashing light at 8 words per minute; and transmit and receive plain language messages by semaphore at 8 words per minute.

LEADERSHIP

As you advance in the Quartermaster rating, you will have more responsibility and authority. You will be required to exercise more leadership than so far has been required of you. You must learn how to handle men. You must set high standards so that your men will follow your example. The type of PO you are, your personal behavior and attitude toward your job, and your professional advancement will influence the type of work your men do.

Information on the practical application of leadership and supervision may be obtained from the current revision of *Military Requirements for Petty Officers 3&2*, NAVEDTRA 10056.

THE NAVY ENLISTED ADVANCEMENT SYSTEM

Many of the rewards of Navy life are earned through the advancement system. The basic ideas behind the system have remained stable for many years, but specific portions may change rapidly. It is important that you know the system and follow changes carefully. BUPERS Notices 1418 will normally keep you up to date.

The normal system of advancement may be easier to understand if it is broken into two parts:

1. Those requirements that must be met before you may be considered for advancement.

2. Those factors that actually determine whether or not you will be advanced.

QUALIFYING FOR ADVANCEMENT

In general, to QUALIFY (be considered) for advancement, you must first:

1. Have a certain amount of time in pay grade.
2. Demonstrate knowledge of material in your mandatory rate training manuals by achieving a suitable score on your command's test, by successfully completing the appropriate NRCCs or, in some cases, by successfully completing an appropriate Navy school.
3. Demonstrate the ability to perform all the practical requirements for advancement by completing the Record of Practical Factors, NAVEDTRA 1414/1.
4. Be recommended by your commanding officer.
5. For petty officer third and second candidates ONLY, demonstrate knowledge of military subjects by passing a locally administered MILITARY/LEADERSHIP examination based on the naval standards for advancement (from NAVPERS 18068 series).
6. Demonstrate knowledge of the technical aspects of your rate by passing a Navywide advancement examination based on the occupational standards applicable to your rate (from NAVPERS 18068 series, those standards listed at and below your rate level).

If you meet all of the above requirements satisfactorily, you become a member of the group from which advancements will be made.

WHO WILL BE ADVANCED?

Advancement is not automatic. Meeting all of the requirements makes you eligible but does not guarantee your advancement. Some of the factors that determine which persons, out of all of those QUALIFIED, will actually be advanced in rate is the score made on the advancement examination, the length of time in service, the performance marks earned, and the number of vacancies being filled in a given rate.

If the number of vacancies in a given rate exceed the number of qualified personnel, then ALL of those qualified will be advanced. More often, the number of qualified people exceeds the vacancies. When this happens, the Navy has devised a procedure for advancing those who are BEST qualified. This procedure is based on combining three personnel evaluation systems:

Merit rating system (Annual evaluation and CO recommendation)
Personnel testing system (Advancement examination score—with some credit for passing previous advancement exams)
Longevity (seniority) system (Time in rate and time in service)

Simply, credit is given for how much the individual has achieved in the three areas of performance, knowledge, and seniority. A composite, known as the final multiple score, is generated from these three factors. All of the candidates who have PASSED the examination from a given advancement population are then placed on one list. Based on the final multiple score, the person with the highest multiple score is ranked first, and so on, down to the person with the lowest multiple score. For E4, E5, and E6, advancement authorizations are then issued, beginning at the top of the list, for the number of persons needed to fill the existing vacancies. Candidates for E7 whose final multiple scores are high enough will be designated PASS SELBD ELIG (Pass Selection Board Eligible). This means that their names will be placed before the Chief Petty Officer Selection Board, a BUPERS board charged with considering all so designated eligible candidates for advancement to CPO. Advancement authorizations for those being advanced to CPO are issued by this board.

Who, then, are the individuals who are advanced? Basically, they are the ones who achieved the most in preparing for advancement. They were not content to just qualify; they went the extra mile in their training, and through that training and their work experience they developed greater skills, learned more, and accepted more responsibility.

While it cannot guarantee that any one person will be advanced, the advancement system does guarantee that all persons within a particular rate will compete equally for the vacancies that exist.

HOW TO PREPARE FOR ADVANCEMENT

What must you do to prepare for advancement? You must study the standards for advancement, work on the practical factors, study the required rate training manuals, and study other material that is required for advancement in your rating. To prepare for advancement, you will need to be familiar with (1) the *Manual of Navy Enlisted Manpower and Personnel Classification and Occupational Standards*, (2) the Record of Practical Factors, (3) a NAVEDTRA publication called *Bibliography for Advancement Study*, NAVEDTRA 10052, and (4) applicable rate training manuals. The following sections describe them and give you some practical suggestions on how to use them in preparing for advancement.

Occupational Standards

The *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards*, NAVPERS 18068-D contains the rating occupational and naval standards for advancement to each pay grade in section I. Contained in section II is the Navy Enlisted Classification Codes. This manual replaces the "quals manual" and the NEC manual.

NAVAL STANDARDS are requirements that apply to all ratings rather than to any one particular rating. Naval requirements for advancement to third class and second class petty officer rates deal with military conduct, naval organization, military justice, security, watchstanding, and other subjects which are required of petty officers in all ratings.

OCCUPATIONAL STANDARDS are requirements that are directly related to the work of each rating.

Both the naval requirements and the occupational standards are divided into subject matter groups.

You are required to pass a Navywide military/leadership examination for E-4 or E-5, as appropriate, before you take the advancement examinations. The military/leadership examinations are administered on a schedule determined by your commanding officer. Candidates are required to pass the applicable military/leadership examination only once. Each of these examinations consists of 100 questions based on information contained in *Military Requirements for Petty Officers 3&2*, NAVEDTRA 10056 (current edition) and in other publications listed in *Bibliography for Advancement Study*, NAVEDTRA 10052 (current edition).

The Navywide occupational examinations for pay grades E-4 and E-5 will contain 150 questions related to occupational areas of your rating. If you are working for advancement to second class, remember that you may be examined on third class standards as well as on second class standards.

NAVPERS 18068-D is kept current by means of annual changes. The occupational standards for your rating which are covered in this training manual were current at the time the manual was printed. By the time you are studying this manual, however, the standards for your rating may have been changed. Never trust any set of standards until you have checked it against an UP-TO-DATE copy of NAVPERS 18068–D.

Record of Practical Factors

Before you can take the Navywide examination for advancement, there must be an entry in your service record to show that you have qualified in the naval and occupational standards. The RECORD OF PRACTICAL FACTORS, mentioned earlier, is used to keep a record of your practical factor standards. This form is available for each rating and lists both military and occupational factors. As you demonstrate your ability to perform each practical factor, appropriate entries are made in the DATE and INITIALS columns by your supervisor or senior petty officer.

Changes are made periodically to the *Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards* and revised forms of NAVEDTRA 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to NAVPERS 18068-D. The Record of Practical Factors also provides a space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum occupational standards.

Until completed, the NAVEDTRA 1414/1 is usually held by your division officer, after completion, it is forwarded to the personnel office for insertion in your service record. If you are transferred before qualifying in all practical factors, the incomplete form should be forwarded with your service record to your next duty station. You can save yourself a lot of trouble by making sure that this form actually is inserted in your service record before you are transferred. If the form is not in your service record, you may be required to start all over again and requalify in the practical factors which have already been checked off.

NAVEDTRA 10052

The *Bibliography for Advancement Study*, NAVEDTRA 10052 (revised), is a very important publication for any enlisted person preparing for advancement. This *Bibliography* lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NAVEDTRA 10052 is revised and issued once each year by the Naval Education and Training Support Command. Each revised edition is identified by a letter following the NAVEDTRA number. When using this publication, be SURE that you have the most recent edition. When you are preparing for advancement, check to see whether changes have been made in the standards for your rating.

The required and recommended references are listed by pay grade in NAVEDTRA 10052. If you are working for advancement to third class, study the material that is listed for third class. If you are working for advancement to second class, study the material that is listed for second class; but remember that you are also responsible for the references listed at the third class level.

In using NAVEDTRA 10052, you will notice that some rate training manuals are marked with an asterisk (*). Any manual marked in this way is MANDATORY–that is, it must be completed at the indicated rate level before you can be eligible to take the Navywide examination for advancement. Each mandatory manual may be completed by (1) passing the appropriate nonresident career course that is based on the mandatory training manual; (2) passing locally prepared tests based on the information given in the training manual; or (3) in some cases, successfully completing an appropriate Navy school.

Do not overlook the section of NAVEDTRA 10052 which lists the required and recommended references relating to the military standards for advancement. Personnel of ALL ratings must complete the mandatory military requirements training manual for the appropriate rate level before they can be eligible to advance.

The references in NAVEDTRA 10052 which are recommended but not mandatory should also be studied carefully. ALL references listed in NAVEDTRA 10052 may be used as source material for the written examinations, at the appropriate rate levels.

Rate Training Manuals

As a result of the establishment of the Naval Education and Training Support Command under the Chief of Naval Education and Training, new editions of rate training manuals, nonresident career courses, curricula, and other training publications formerly designated by the abbreviations NAVPERS are being designated NAVEDTRA. This training manual, for example, is NAVEDTRA 10149-F, which means that is a publication of the Naval Education and Training Support Command and succeeds a manual designated NAVPERS 10149-E.

In this chapter and elsewhere in this manual, training publications which already carry the new abbreviations are so listed; those not yet changed are listed as NAVPERS numbers.

There are two general types of rate training manuals. RATING MANUALS (such as this one) are prepared for most enlisted ratings. A rate training manual gives information that is directly related to the occupational standards of ONE rating. SUBJECT MATTER manuals or BASIC manuals give information that applies to more than one rating.

Rate training manuals are revised from time to time to keep them up to date technically. The revision of a rate training manual is identified by a letter following the NAVPERS, NAVTRA, or NAVEDTRA number. You can tell whether any particular copy of a training manual is the latest edition by checking the NAVPERS, NAVTRA or NAVEDTRA number and the letter following this number in the most recent edition of *List of Training Manuals and Correspondence Courses*, NAVEDTRA 10061. (NAVEDTRA 10061 is actually a catalog that lists all current training manuals and nonresident career courses; you will find that this catalog is useful in planning your study program.)

Each time a rate training manual is revised, it is brought into conformance with the official publications and directives on which it is based; but during the life of any edition, discrepancies between the manual and the official sources are almost certain to arise because of changes to the latter which are issued in the interim. In the performance of your duties, you should always refer to the appropriate official publication or directive. If the official source is listed in NAVEDTRA 10052, the Naval Education and Training Program Development Center uses it as a source of questions in preparing the fleetwide examinations for advancement. In case of discrepancy between any publications listed in NAVEDTRA 10052 for a given rate, the Naval Education and Training Program Development Center will use the most recent material.

Rate training manuals are designed to help you prepare for advancement. The following suggestions may help you make the best use of this manual and other Navy training publications when you are preparing for advancement.

1. Study the naval standards and the occupational standards for your rating before you study the training manual, and refer to them frequently as you study. Remember, you are studying the manual primarily to meet these standards.
2. Set up a regular study plan. It will probably be easier for you to stick to the same time each day. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.
3. Before you begin to study any part of the manual intensively, become familiar with the entire book. Read the preface and the table of

contents. Check through the index. Look at the appendices. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

4. Look at the training manual in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a clear picture of the scope and content of the book. As you look through the book in this way, ask yourself some questions.

What do I need to learn about this?
What do I already know about this?
How is this information related to information given in other chapters?
How is this information related to the standards for advancement?

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material that you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying any one unit—chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how the information ties in with your own past experience.

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered, but perhaps you still have some that are not answered. Without looking at the training manual, write down the main ideas that you have gotten from studying this unit. Don't just quote the book. If you can't give these ideas in your own words, the chances are that you have not really mastered the information.

9. Use nonresident career courses whenever you can. The nonresident career courses are based on rate training manuals or on other appropriate texts. As mentioned before, completion of a mandatory rate training manual can be accomplished by passing a nonresident career course based on the rate training manual. You will probably find it helpful to take other nonresident career courses, as well as those based on mandatory training manuals. Taking a nonresident career course helps you to master the information given in the training manual, and also helps you see how much you have learned.

10. Think of your future as you study rate training manuals. You are working for advancement to third class or second class right now, but someday you will be working toward higher rates. Anything extra that you can learn now will help you both now and later.

SOURCES OF INFORMATION

Besides training manuals, NAVEDTRA 10052 lists official publications on which you may be examined. You should not only study the sections required; but should become as familiar as possible with all publications you use.

One of the most useful things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the naval requirements for advancement and the occupational standards of your rating.

Some of the publications discussed here are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been entered.

Official publications and directives carry abbreviations and numbers which identify the source of the document and its subject matter. An abbreviation designates the publisher (e.g., NAVPERS, OPNAV), and the numerals that follow indicate the series of related issuances to which the publication belongs. The letter following the numerals designates the edition.

Because you should always make it your responsibility to see that you are using the latest edition of any publication or directive, this training manual usually does not show the final letter referring to a publication or directive.

A great deal of written material with which a Quartermaster should be familiar is in reference books. It is recommended that the following works be referred to for valuable elaboration of subjects discussed in this manual: ACPs 118, 125, 129; Manual for Ship's Surface Weather Observations, NAVWEASERVCOMINST 3144.1; American Practical Navigator (Bowditch), Pub. No. 9, Vol. I and II; Maneuvering Board Manual, Pub. No. 217; The Watch Officer's Guide, Dutton's Navigation and Piloting, and Marine Navigation (Hobbs) Vol. I and II.

If some section of this training course puzzles you, or you feel a need to know more details about a specific operation, you should refer to the books just listed. These books should be readily available aboard your ship. If they are not, your division officer will request them through proper channels.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Training films are listed in the *United States Navy Film Catalog*, NAVAIR 10–1–777, published 1 July 1971. Copies may be ordered in accordance with the *Navy Stock List of Forms and Publications*, NAVSUP 2002. Supplements to the Film Catalog are distributed to catalog holders.

When selecting a film, note its date of issue listed in the Film Catalog. As you know, procedures sometimes change rapidly. Thus some films become obsolete rapidly. If a film is obsolete only in part, it may sometimes be shown effectively if before or during its showing you carefully point out to trainees the procedures that have changed. For this reason, if you are showing a film to train other personnel, take a look at it in advance if possible so that you may spot material that may become obsolete and verify current procedures by looking them up in the appropriate sources before the formal showing.

METRIC SYSTEM

The Metric System Single-Subject Training Manual and its associated OCC-ECC form a self-study package (NAVEDTRA 475-01-00-75) to train Navy personnel in conversion from the U.S. Customary System to the International System (SI). Order the SSTM by stock number 0507-LP-475-0000 from NPFC, Philadelphia, PA. and the OCC-ECC by NAVEDTRA 475-01-00-75 from NAVEDTRAPRODEVCEN, Pensacola, Florida, 32559.

CHAPTER 2

QUARTERMASTER WATCHES

One of the most important bridge watches is the quartermaster watch. As a member of the watch team, every Quartermaster must serve as an observer and as a recorder.

Being an observer is one of the duties of the quartermaster of the watch. He should make every effort to find out as much as he can about the bridge, its functions, and its personnel because he frequently is assigned the job of enlisted supervisor of the watch. This assignment occurs particularly on smaller ships that have no boatswain's mate of the watch, and on all ships during general quarters. The quartermaster of the watch must keep his eyes open for any routine that is overlooked or neglected. He also must be on the alert for any unusual occurrences.

The QM of the watch should not hesitate to bring any unusual incident to the attention of the OOD, the boatswain's mate of the watch, or any other member of the watch. The purpose of a watch is to maintain the safety of the ship and the men. It behooves all members of the watch to be vigilant.

It is the aim of this chapter to familiarize you with the bridge, bridge personnel, bridge equipment, and the duties a Quartermaster performs while standing quartermaster watches.

UNDERWAY

When you relieve the watch, make sure you obtain any special information the man you relieve may have for you. Such information includes verbal orders to the wheel that still are standing, steering peculiarities due to unusual weather situations, or anticipated aids to navigation.

Consult the night order book and examine the current orders. Look over the deck log entries of the previous watch and see if there is anything pertaining to your watch, then report officially to the OOD that you have relieved the watch.

Inform yourself of the general situation. You should have some knowledge of what is happening aboard your ship. The material which follows will give you an idea of some of the information you must know when you stand watch. How much information you need depends to some degree on whether you are anchored, at sea, alongside, or in some other situation.

First (and most important), as the quartermaster of the watch, you serve as the assistant to the OOD. In this capacity you are very close to events occurring on the bridge and at other stations. Your nearness makes it possible for you to observe the watch personnel and the jobs they are performing. Frequently, the officer of the deck is involved in a problem of maneuvering or navigation, and may fail to notice the omission of small details in the ship's daily routine. Pages from the ship's organization book, listing the routine of the day, are available in the pilothouse. It is an important part of your job as quartermaster of the watch to remind people concerned when the time approaches for performing each detail.

When standing watch, you should observe all instruments and equipment that register and perform significant functions. If, for instance, the steersman wanders off course, you should, by your observation of the compass, be the first to discover what happened. This incident should be reported to the OOD immediately. The barometer is another instrument that you should keep your eye on. The barometer readings are entered in the weather log every hour. Other instruments that you should observe closely are the rudder angle indicator, course recorder, and revolution indicator. Anything that might affect the ship should be reported to the OOD.

The condition of the ship's motive powerplant must be known at all times. Underway, the boilers and engines in use must be recorded.

As watch quartermaster you must know your ship's standard speed and how many revolutions per minute are required to make standard speed. Naturally, you must know the speed she is making presently, her base course by steering, standard and gyrocompass, and her present course.

Check to see that the required running lights and auxiliary lights are on at night. If you have the watch at sunrise or sunset, turn the required lights on or off at the proper instant. Having the proper lights on is a must for every naval vessel. A knowledge of lights enables you to determine the direction another ship is traveling. If the wrong lights are used, your ship may become endangered. For correct ship's lights, refer to chapter 6 of this training manual.

As quartermaster of the watch, you should know the cruising formation of the ship, and the name and location of the other ships present. You must know your ship's relative position in formation, and check it repeatedly during the watch. You should know how to work basic maneuvering board problems. The maneuvering board problems are essential in determining courses and speeds to use if the formation is altered.

Find out which boat is designated ready lifeboat, and learn the plan for manning it.

Always arrive on station at least 15 minutes ahead of the scheduled time for relieving the watch: nothing is more aggravating than a late relief. More important, you must obtain much information about the general situation before you can assume responsibility.

You must be able at all times to locate the various notebooks and records you are to use during the watch. These record books include the ship's deck log, the captain's night order book, the morning call book, and the magnetic compass record.

The morning call book contains a list of the people who are to be called early. When you relieve the midwatch, take a look at the call book at once and note the time the earliest call is to be made. Because you shouldn't leave the bridge during your watch, the calls should be made by the messenger, but you are responsible for keeping the messenger informed.

The captain's night order book contains a summary of the duties of the bridge watch. Although actually addressed to the officer of the deck, its contents must be equally familiar to his assistant, the quartermaster of the watch. Standing orders usually are posted inside the front cover of the night order book. Each day, on a separate page the captain inserts a description of the general situation at the end of that day and any special orders (called current orders) that apply to succeeding watches.

The OOD and usually the JOOD, CIC watch officer, and CIC watch supervisor are required to initial the current night orders to signify they have read and understand them. When you check the orders, be sure you are looking at the correct page. It has happened that wrong pages have been read, and the resulting troubles can be serious. For this reason, always check the date of the current orders you are inspecting. Shortly in advance of the time for the officer of the deck to execute the orders directed to him in the night order book, it is advisable to remind him of this duty.

You must also be able to find the apparatus you are to use—engine order telegraph, rpm indicator, echo depth sounder, barometer, bearing circle, stadimeter, light switches, and controls for any electrical signal equipment operated from the navigation and signal bridges—even under conditions of total darkness.

INPORT

The quartermaster of the watch (when assigned) will perform duties assigned him by the officer of the deck and in accordance with the instructions of the navigator. He will be responsible to the officer of the deck for making entries in the deck log. He will also execute sunrise and sunset, ensure the proper handling of absentee pennants, turning on and off anchor and riding lights, hail boats, and assist the officer of the deck in rendering honors.

Keep an eye on the weather situation, tendency of the barometer, wind velocity and direction, cloud formations, and any other conditions that might endanger your ship. If any of the ship's boats are in the water, you must know their location and any special orders applicable to them. You must have the compass course to the regular landing worked out for boat coxswains, and be prepared to work out a course for any boat making a trip to another point.

One of your main duties as the quartermaster of the watch on an anchored ship is to see whether the ship drags her anchor. You must know what kind of holding ground the anchor is in (mud, sand, gravel) and how deep the water is. Be alert at all times to detect the first indication of dragging, especially when circumstances make it a definite possibility. Poor holding ground, deep water, a strong wind or tide, or any combination of these conditions means that the drift lead should be put over at once and checked often. Repeated bearings and ranges must then be taken. You must report to the OOD any indication of a drag, even though it is only a suspicion. You must learn to distinguish between a change of bearing caused by a swing, and the actual change due to dragging.

Immediate action must be taken when the anchor starts to drag. It may be necessary only to veer chain and get another good bite. In a crowded anchorage or near a lee shore of shoal water, however, another anchor must be dropped at once. Preparations usually are made for getting underway, and emergency signals are made to warn ships to leeward of downstream that they may have to maneuver out of the way.

If your ship is moored with two anchors, you must know whether a swivel is in use. If not, or if the swivel is not functioning properly, you must keep record of how the ship swings so you can inform the OOD before the chain becomes fouled. This action entails a knowledge of the state of the tide. If you are moored alongside, you must know what lines are in use, whether they are doubled up, and whether they are taut or slack. If your ship is one of a nest, you must know which ship in the nest has the buoy. You should also know the duty, liberty, and standby sections; the name of the command duty officer, the duty department heads; and whether the captain and executive officer are ashore. You will also maintain a call book and instruct the messenger in calling officers and men at specified times.

BRIDGE PERSONNEL

The numbers and assignments of personnel on watch vary from ship to ship, depending on the ship's size and availability of personnel.

The watch on the bridge, underway, normally consists of the following personnel:

Officer of the deck
Junior officer of the deck
Boatswain's mate of the watch
Quartermaster of the watch
Helmsman
Lee helmsman (who usually mans the engine order telegraph);
Sound-powered telephone talker
Messenger
Lookouts

Some of the primary jobs on the bridge are the the OOD, BMOW, and helmsman.

The officer of the deck is primarily responsible, under the commanding officer, for the safe and proper operation of the ship. He has many duties that are too numerous to cover here. OPNAVINST 3120.32 gives the duties, responsibilities, and authority in detail.

The BMOW has the primary duty of aiding the OOD in carrying out the ship's routine and ensuring the efficient functioning of the watch. In addition he shall aid the OOD in supervising and instructing members of the watch and report to the OOD when the watch has been properly relieved.

The helmsman must be a qualified steersman with such qualifications recorded in his service record.

BRIDGE EQUIPMENT

The bridge contains instruments or apparatus for–

- Steering
- Depth sounding
- Indicating ship's heading
- Indicating rudder angle
- Measuring speed
- Measuring temperature and atmospheric pressure
- Communicating speed orders to engineroom
- Taking bearings and ranges
- Making celestial observations
- Plotting ship's position and course
- Controlling running and speed lights
- Indicating revolutions made by the engines
- Communicating with other departments in the ship and with other ships
- Measuring wind direction and speed

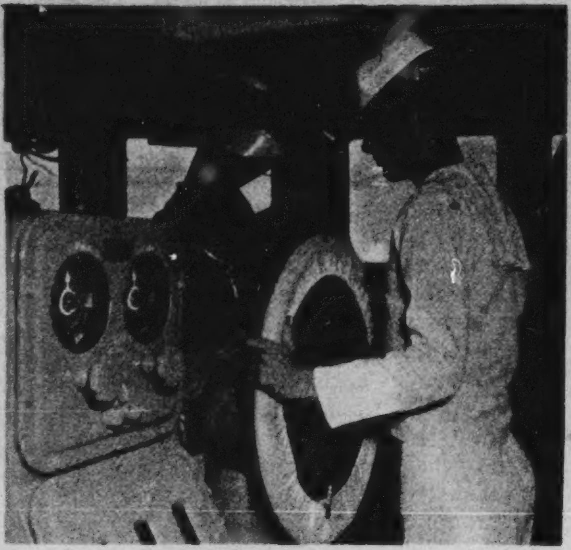
A rated Quartermaster seldom stands routine helmsman watches nowadays. He does, however, take over during emergencies and in some special circumstances. Some ships whose steering engines are controlled by a "streetcar" controller have only a miniature wheel, or sometimes just a lever, for putting over the rudder. Most ships have steering unit similar to that shown in figure 2–1.

Forward of the wheel, where the helmsman can see it best, is the magnetic steering compass in its binnacle, and to one side, either one or two gyro repeaters. Nearby is the engine order telegraph with separate handles, port and starboard, for twin screws, or a single handle for a single-screw ship. The engine revolution indicator usually is rigged on or near the telegraph. A rudder angle indicator is on the forward bulkhead, or in some position where it can be seen easily by the steersman. Ordinarily a wheel angle indicator is mounted on the steering post itself. Voice tubes, telephones, the PA system, and the howler and gong control are customarily on the after bulkhead. Light switchboards and various indicators, such as the aneroid barometer and deck clock, usually are on one of the side bulkheads. In the pilothouse on most ships is a radar repeater with a plan position indicator (PPI) scope that shows the position of all the ships in formation, or other objects nearby.

The charthouse normally is abaft the wheelhouse, but may be located on another deck some distance away. Here the chart portfolios are laid out on shelves or are stowed away in drawers. A table for laying out charts generally is equipped with a universal drafting machine; The dead-reckoning tracer (DRT) may be set up here too.

Shelves in the charthouse contain the navigational instruments–sextants, stadimeters, bearing circles, stopwatches, etc. Plotting tools stowed in boxes or drawers include parallel rulers, dividers, protractors, Star Finder and Identifier (No. 2102–D), Hoey position plotters, and such paraphernalia as pencils, stamps, inks, and erasers.

A chronometer case usually is installed in the charthouse. Built-in shelves contain the navigator's library, hydrographic publications, tide and current tables, etc.



69.1

Figure 2-1.– Bridge of a destroyer.

PREPARATIONS FOR GETTING UNDERWAY

A ship cannot get underway unless extensive preparations are made. During these preparations, every department and nearly every man has some duties to perform. As Quartermaster, you have some of the most important duties.

Your duties in connection with getting underway may be separated into two broad categories. First, you must lay out and set up equipment. Second, you must check or test the operating equipment on the bridge.

SETTING UP EQUIPMENT

You must set up the navigational chart of the area in which your ship is anchored or moored. Provide pencils, dividers, drawing compasses, parallel rulers, and erasers for the use of the navigator. Set up a drafting machine, bearing circle, and alidade. When required, you may also need a three-arm protractor, sextant, and stadimeter. You, must also provide binoculars for the bridge personnel.

CHECKING AND TESTING EQUIPMENT

The operating equipment on the bridge must be tested to ensure that it will function properly when the ship is underway. You must check the helm and rudder by turning the wheel full to the right (or left) and watching the rudder angle indicator to see that it follows the wheel angle indicator to the proper angle. When this check is made, turn the wheel full in the opposite direction, and again watch the rudder angle indicator for proper reaction. While this test is being carried out, you should have someone in after steering standing by to see that the wheel and the rudder angle indicator at that steering station are functioning properly.

The QM of the watch tests the annunciator and propeller revolution telegraph to ensure that the necessary signals can be transmitted to the engineroom. Prior arrangements for the test must be made with engineroom and I.C. room personnel. To test the annunciator, move the handle on either the port or starboard side to one of the positions that indicates a desired speed (ahead or astern); wait for the engineroom personnel to acknowledge receipt of the order by moving their indicator to the same position. When the engineroom acknowledges, repeat the procedure by using a different indication of speed. Continue in this manner until all handle positions on the annunciator are indicated and acknowledged.

Test the propeller revolution indicator by indicator by turning the indicator knobs, thereby causing different numbers of desired revolutions to be transmitted to the engineroom. Personnel in the engineroom should acknowledge by indicating the same number of revolutions rung up by the bridge. This procedure should be repeated, using several different combinations of numbers.

Check the gyrocompass repeaters to see that they are aligned with the master. Accomplish this procedure by "marking" the repeaters and the master simultaneously, then compare the readings. If the reading at the lubber's line of a repeater differs from the master by half a degree or more, you should realign it. Proceed by pushing in and rotating an adjusting knob, located near the base of the repeater, either clockwise or counterclockwise, so that the compass card on the repeater can be rotated to coincide with the master gyro.

The ship's whistle and siren (if installed on your ship), as well as the general, chemical, and collision alarms, are additional checks you must make for their proper operation. Before testing any noise-making equipment, however, you must obtain permission from the commanding officer.

SHIP'S DECK LOG

The deck log is the official daily record of a ship, by watches, in which is described every circumstance and occurrence of importance or interest which concerns the crew and the operation and safety of the ship or which may be of historical value. The quartermaster of the watch, under the supervision of the OOD usually keeps the log.

All ships prepare an original and one copy of the deck log. The original log is submitted to the Chief of Naval Operations monthly for permanent retention, and the copy is retained on board ship for a period of six months, after which time, it may be destroyed.

Each event is recorded at the time it happens or as directed by the officer of the deck. All entries will be made with a ballpoint pen, using black or blue-black ink. The officer of the deck affixes his signature to the log following the last entry made during his watch. His name also is stamped or printed beneath his signature.

The navigator examines the Ship's Deck Log daily and takes such corrective action as may be necessary, and within his authority, to ensure that it is properly kept. When each month's log is complete, he certifies the correctness of its contents in the spaces provided on the Ship's Deck Log-Title Page. Daily signature of the navigator is not required.

The commanding officer approves the log at the end of each month, when relieved of command, or when the ship is decommissioned. He signifies his approval by signing both the original and duplicate logs in the space provided on the title page. When a change of command occurs during the month, the title page of that month's log shall bear the signature of each commanding officer, indicating the date the change of command occurred. The log shall not be terminated for submission upon a change of command, but shall be submitted in its entirety at the end of the month.

ASSEMBLY AND DISPOSITION

Each month's log shall be assembled beginning with the title page, followed by the deck log sheets assembled unnumbered and in chronological order. The log pages for the month shall be secured by roundhead paper fasteners or ribbon. Staples or other types of permanent binding shall not be used.

On the first day of each month, or within 10 days thereafter, the original deck log for the previous month shall be forwarded directly to the Chief of Naval Operations or, if required, via the administrative commander. NOTE: Those ships that are on extended patrol or conducting special operations and unable to submit logs as required herein shall forward their monthly deck log(s) to the Chief of Naval Operations within 10 days upon reaching port.

ABBREVIATIONS

Abbreviations in the deck log shall be limited to those generally accepted throughout the Navy by reason of long and continued usage. Obscure or purely communication-type abbreviations shall not be used. The following is a partial listing of the more commonly used abbreviations:

UA	Unauthorized absence
CPA	Closet point of approach
OCE	Officer conducting the exercise
OOD	Officer of the deck
OTC	Officer in tactical command
Commands	COMCARGRU 7, CINCPACFLT, etc.
R(L)FR	RIGHT (LEFT) FULL RUDDER
R(L)15R	RIGHT (LEFT) 15 DEGREES RUDDER
H(R/L)R	HARD RIGHT (LEFT) RUDDER
R/A	RUDDER AMIDSHIP
MEET HR	MEET HER
R(L)050	RIGHT (LEFT) TO COURSE 050
AEA 1/3	ALL ENGINES AHEAD 1/3
AE STOP	ALL ENGINES STOP
AEA STD	ALL ENGINES AHEAD STANDARD
AEA FUL	ALL ENGINES AHEAD FULL
AEA FLK	ALL ENGINES AHEAD FLANK
P(S)EA 1/3 . . .	PORT (STARBOARD) ENGINE AHEAD 1/3
P(S)EB 1/3 . . .	PORT (STARBOARD) ENGINE BACK 1/3
145 RPM	INDICATE 145 RPM

REQUIRED SHIP'S DECK LOG ENTRIES

Every injury, accident, or casualty, however slight, among the officers, crew, passengers, visitors, longshoremen, harborworkers, or repairmen on board must be recorded. The large number of claims for pensions or other compensation submitted by persons alleging injury make this information of great importance to the Government, both to protect it from false claims and to furnish a record for bona fide claims. Therefore, care must be taken to record the full particulars in each instance.

1. All peculiar or extraordinary appearances of the sea, atmosphere, or heavens, preceding or following sudden changes of wind, heavy squalls of wind, or of heavy gales.

2. All unusual appearances of the sea, tide rips, discolored water, extraordinary luminescence of the sea, strange birds, fishes, icebergs, driftwood, seaweed, etc.

3. All unusual meteorological phenomena, extraordinary refractions, waterspouts, meteors, shooting stars, auroras, halos, fata morganas, iceblinks, corposantos, etc. and all earth satellites.

4. The behavior of the vessel under different circumstances of weather and sea, such as pitching, rolling, weathering qualities, etc.

5. The sighting of vessels, land lighthouses, lightships, and all dangers to navigation, with time, bearings and distances.

6. The bearing and distance of the object taken for a departure.

7. Any soundings, the record of which is important with character of the bottom.

8. After anchoring, recording bearings and angles such as to enable the exact position of the ship to be located on the chart.

9. After anchoring in unfrequented ports, roadsteads, or on strange coasts, the bearings of all prominent objects on shore, adjacent points, islands, rocks, or dangers, and the depth of the water within the distance required for working ship.

10. When at anchor, the commencement of flood and ebb tides, the time of slack water, and the time the vessel swings to her anchor upon a change of tide.

11. When at anchor in heavy weather, the strain upon the cables, etc.

12. A summary of the orders under which the ship moves, quoting the authority for the orders, etc. In general, this entry should show the character of the duty on which the ship is engaged and the reasons for her movements in order that it may be of historical value.

13. The time of reporting to or detachment from any fleet, task force (or subdivision thereof), or tactical unit.

14. Tactical formation of the ships in company and major changes thereto.

15. The time when any particular evolution, exercise, or other service was performed (receiving a pilot, preparing to enter port or to anchor, anchorage, depth of water, bearings, etc.; getting underway, discharging pilot, securing anchors, securing battery, preparing ship for sea, and major engineering changes).

16. All speed changes in knots.

17. All courses and bearings, interpreted to read "degrees true" unless otherwise indicated.

18. All occurrences of importance and interest, including change of command, official visits, salutes fired, and flags displayed.

19. All formal inspections concerning personnel, material, records, combat readiness, etc., conducted by the commanding officer or an officer senior to him.

20. All alterations in allowance of fresh water per man, with reasons, etc.

21. All accidents resulting in loss of any kind. The loss or serious damage to boats, other equipage and stores of any kind with the attendant circumstances.

22. After an action, a full, detailed account of every occurrence and remarkable incident, all damage to hull, equipage, and machinery, all killed and wounded, etc.

23. All prisoners taken by an enemy.

24. The grounding of the ship, with all attendant circumstances.

25. The name, grade and social security number of all officers who may join or be transferred from the ship, other than those received or lost by reason of permanent change of station.

26. All unexplained or unauthorized absentees, with indication of time of occurrence and first knowledge of absence, surrounding circumstances, and time and circumstances of later whereabouts or fate.

27. All deaths on board, with a statement as to exact time and cause of death.

28. The names of all passengers, with the time of coming on board and leaving.

29. All meetings of courts-martial and formal boards with the dates and times of commencement, recess and adjournment, as well as the findings and sentence of each court-martial.

30. All arrests, suspensions from duty, and restorations to duty, with dates and times of occurrence and surrounding circumstances.

SAMPLE SHIP'S DECK LOG ENTRIES

The sample entries listed herein are guides for recording entries in the log. Any such listing, of course, cannot be all inclusive, nor can the sample entries be construed as the only acceptable ones. Any entry that is complete, accurate and couched in standard naval phraseology is acceptable. For a more complete listing see OPNAVINST 3100.7, Revised procedure for keeping the Ship's Deck Log.

Since the deck log is handwritten, particular care must be taken when recording numbers. Proper nouns shall be printed. Logs received in the Chief of Naval Operations which are illegible (including poor penmanship) will be returned for remedial action.

When a correction is deemed necessary, a single line shall be drawn through the original entry so that the entry remains legible. The correct entry shall then be inserted in such manner as to ensure clarity and legibility. Corrections, additions, or changes shall be made only by the person required to sign the record for the watch, and shall be initialed by him on the margin of the page.

Daily Initial Watch Entries

Underway

00-04

0000 Steaming in company with Task Group 58.1, composed of CARGRU 1, CRUDESFLOT 3 and DESRON 5, plus *USS AULT* (DD-698) and *USS BORIE* (DD-704), enroute from Pearl Harbor, Hawaii, to Guam, M.I. (Operating at sea off the coast of California), in accordance with CTG 58.1 serial 061. This ship in station____ in formation ____. Formation course____; speed ____knots. Formation axis____. SOPA is CTG 58.1 in *USS CHICAGO* (CG-11). OTC is COMCARGRU 1 in *USS CONSTELLATION* (CV-64). *CHICAGO* is guide, bearing____, distance____ yards. Condition of readiness TWO and material condition ____set. Ship darkened (except for running lights).

NOTE: On succeeding watches the first entry is "Underway as before."

In Port

00-08

0000 Moored starboard side to *USS HARLAN R. DICKSON* (DD-708) with standard mooring lines in a nest of three destroyers. *USS DAVIS* (DD-937) moored outboard of *HARLAN R. DICKSON* to starboard. *HARLAN R. DICKSON* moored fore and aft to buoys B-5 and B-6, San Diego, Calif. Ships present:____, SOPA____.

00-03

0000 Anchored in Berth B-4, U.S. Naval Operating Base, Trinidad, The West Indies, in 12 fathoms of water, mud bottom, with 60 fathoms of chain to the starboard anchor on the following anchorage bearings: South Point Light 060, etc. Ship in condition of readiness THREE, material condition____ set and darkened except for anchor lights. Engineering Department on 30 minutes notice before getting underway. Heavy weather plan____ in effect. Anchor detail standing by. Wind 45 knots from 070. Weather reports indicate possibility of winds up to 60 knots before 0400. Ships present:____, SOPA____.

00-08

0000 Moored starboard side to Pier 3, Berth 35, U.S. Naval Base, Norfolk, Va., with standard mooring lines doubled.

Receiving miscellaneous services from the pier. Ships present include ____, SOPA ____.

00-24

0000 Resting on keel blocks in Drydock Number 3, U.S. Naval Shipyard Bremerton, Wash., receiving miscellaneous services from the dock. Ships present include ____, SOPA ____.

NOTE: On succeeding watches the first entry is "Moored as before," "Anchored as before," or "Dry-docked as before."

Formation

0700 Maneuvering to take station ____ in formation ____, axis ____. Guide is *USS LITTLE ROCK* (CG-4) in station ____.

0800 Rotated formation axis to ____.

0900 Formation changed from 49 to 52. New Formation Guide is *USS LONG BEACH* (CGN-9) in station ____.

Officer in Tactical Command (OTC)

0900 COMCARGRU 3 embarked in *USS RANGER* (CV-61) assumed OTC.

1000 Commanding Officer, *USS NIMITZ* (CVN-68) was designated OTC.

NOTE: Log all shifts of tactical command. When the OTC is the commanding officer of your ship, use the following terminology: "OTC is Commanding Officer, *USS FRANKLIN D. ROOSEVELT* (CV-42)." In every case, use the command title of the OTC (e.g., COMCARGRU 2) and not his name and grade. State in which ship the OTC is embarked.

Fueling

In Port

1000 Commenced fueling from (*USS NEOSHO* (AO-143) (Naval Fuel Depot, Craney Island), draft forward ____, aft ____.

At Sea

1345 Set the Special Sea and Replenishment detail. Commenced preparations for refueling from *USS CHUKAWAN* (AO-100).

1426 Maneuvering to take station astern *USS CHUKAWAN* (AO-100).

1438 On station.

1442 Commenced approach. Captain (at the conn) (conning).

1453 On station alongside port of *CHUKAWAN*.

1456 First line over.

1510 Received first fuel hose.

1515 Commenced receiving fuel.

1559 Fueling completed.

1606 All lines and hoses clear. Maneuvering to clear portside of *CHUKAWAN*.

1612 Clear of *CHUKAWAN*.

1612 Secured the replenishment detail.

Inspections

Administrative, Personnel, Readiness

0930 RADM S. DECATUR, USN, COMTRAPAC, accompanied by members of his staff and inspecting party from *USS ORISKANY* (CV-34) came on board and commenced surprise (administrative) (personnel) (readiness) inspection. Broke flag of COMTRAPAC.

1100 COMTRAPAC, members of his staff and inspecting party left the ship. Hauled down flag of COMTRAPAC.

1110 COMTRAPAC broke his flag in *USS ORISKANY* (CV-34).

Lower Deck

1315 Commenced Captain's inspection of lower decks, holds, and storerooms.

1400 Secured from inspection.

Personnel

0900 Mustered the crew at quarters for Captain's inspection (of personnel and upper decks).

1010 Secured from inspection.

Navigational Entries

Anchoring

1600 Anchored in Area South HOTEL, Berth 44, Hampton Roads, Va., in 4 fathoms of water, mud bottom, with 30 fathoms of chain to the port anchor on the following bearings: Fort Wool, 040, Middle Ground Light 217, Sewall's Point 072. Ships present: ____, SOPA ____.

Contacts

1405 Sighted merchant ship bearing 280, distance about 6 miles on approximately parallel course.

1430 Identified merchant ship as *SS SEAKAY*, U.S. registry, routed independently from Aruba, NWI, to New York, N.Y.

1441 Passed *SS SEAKAY* abeam to port, distance about 2 miles.

1620 Obtained unidentified radar contact bearing 090, distance 28,800 yards (14 miles).

1629 Unidentified contact tracked and determined to be on course 180, speed 15 knots. CPA 042, distance 4.2 miles.

1636 Contact identified as *USS HOEL* (DDG-13) by *USS JOSEPH P. KENNEDY, JR.* (DD-850).

1715 Obtained sonar contact bearing 172, range 2500 yards.

1717 Contact evaluated as possible submarine. Commenced attack (tracking) (investigation).

1720 Lost contact.

1721 Contact regained bearing 020 range ____. Oil slick sighted on that bearing and range. Commenced re-attack.

1724 Sonar reported hearing breaking up noises.

1725 Contact lost.

NOTES: (1) Contacts at sea are logged when they will pass in vicinity of your ship.

(2) Under certain circumstances, contact entries are not made in the log because of their classification or their entry in war diary or action report.

Drydocking

1420 Commercial Tug *SEAGOOSE* came alongside to port. Pilot C.U. FINE came aboard.

1426 U.S. Navy Tug YTB-68 came alongside port bow, U.S. Navy Tug YTB-63 came alongside port quarter.

1430 First line to dock starboard bow.

1435 First line to dock port bow.

1440 Bow passed over sill of dock.

1442 Cast off all tugs.

1450 Caisson in place.

1455 Commenced pumping water out of drydock.

1540 Resting on keel blocks.

1545 Pilot left the ship.

1550 Commenced receiving electrical power, fresh and flushing water from the dock.

1630 Inspection completed of all hull openings.

Overhaul/Conversion/Inactivation

1635 Commenced undergoing (overhaul) (conversion) (inactivation). Commenced limited log entries for duration of (overhaul) (conversion) (inactivation).

NOTE: Upon termination of overhaul or conversion, deck log entries shall commence to be recorded daily by watches.

Undocking

0850 Inspection completed of all hull openings.

0900 Flooding commenced in drydock.

0918 All services disconnected from ship.

0920 Inspection completed of all spaces for watertight integrity.

0925 Ship clear of keel blocks.

0930 Handling lines secure on ship.

0935 Pilot C.U. FINE came aboard.

0950 Commenced moving ship clear of dock.

0958 Stern passed over sill.

1005 U.S. Navy Tug YTB-63 came alongside port bow, U.S. Navy Tug YTB-68 came alongside port quarter.

1009 Bow passed over sill.

Entering Harbor

0551 Passed Ambrose Lightship abeam to port, distance 1000 yards.

0554 Stationed special sea detail. OOD (conning) (at the conn), Captain and Navigator on the bridge.

0600 Commenced maneuvering while conforming to Gedney Channel.

0650 Passed lighted buoy No. 12 abeam to starboard.

0705 U.S. Navy Tug No. 216 came alongside port quarter. Pilot B.A. WATCHER came aboard and took the conn.

0706 Maneuvering to go alongside the pier.

0715 Moored port side to Berth 3A, U.S. Naval Ammunition Depot, Earle, N.J., with standard mooring lines. Ships present: ____, SOPA is COMDESRON 22 in *USS LAWRENCE* (DDG-4).

0720 Pilot left the ship.

Sighting Aids to Navigation

0102 Sighted Cape Henry Light bearing 225, distance about 20 miles.

0157 Passed Cape Henry Light abeam to starboard, distance 7.3 miles.

0300 Cape Henry Light passed from view bearing 315, distance about 20 miles.

Getting Underway

0600 Commended preparations for getting underway. Set material condition ____.

0730 Stationed the special sea detail.

0750 Completed all preparations for getting underway. Draft forward ____, aft ____.

0800 Underway for Norfolk, Va. (for sea), as a unit of Task Group 70.2 in compliance with COMCARGRU 4 serial 063 (CTG 70.2 Op Order 7-73). Maneuvering to clear the anchorage. Captain (conning) (at the conn), Navigator on the bridge.

0810 Standing out of Boston Harbor.

0830 OOD was given the conn. Set readiness condition THREE, anchor detail on deck. (Secured the special sea detail, set the regular steaming watch.)

0845 Entered international waters.

Sea/Weather

1130 Visibility decreased to one mile due to fog (heavy rain). Commenced sounding fog signals and stationed (extra lookouts) (lookouts in the eyes of the ship). Winds southeast 25 knots. Sea southeast 8 feet and increasing.

1212 Visibility increased to 5 miles. Ceased sounding fog signals.

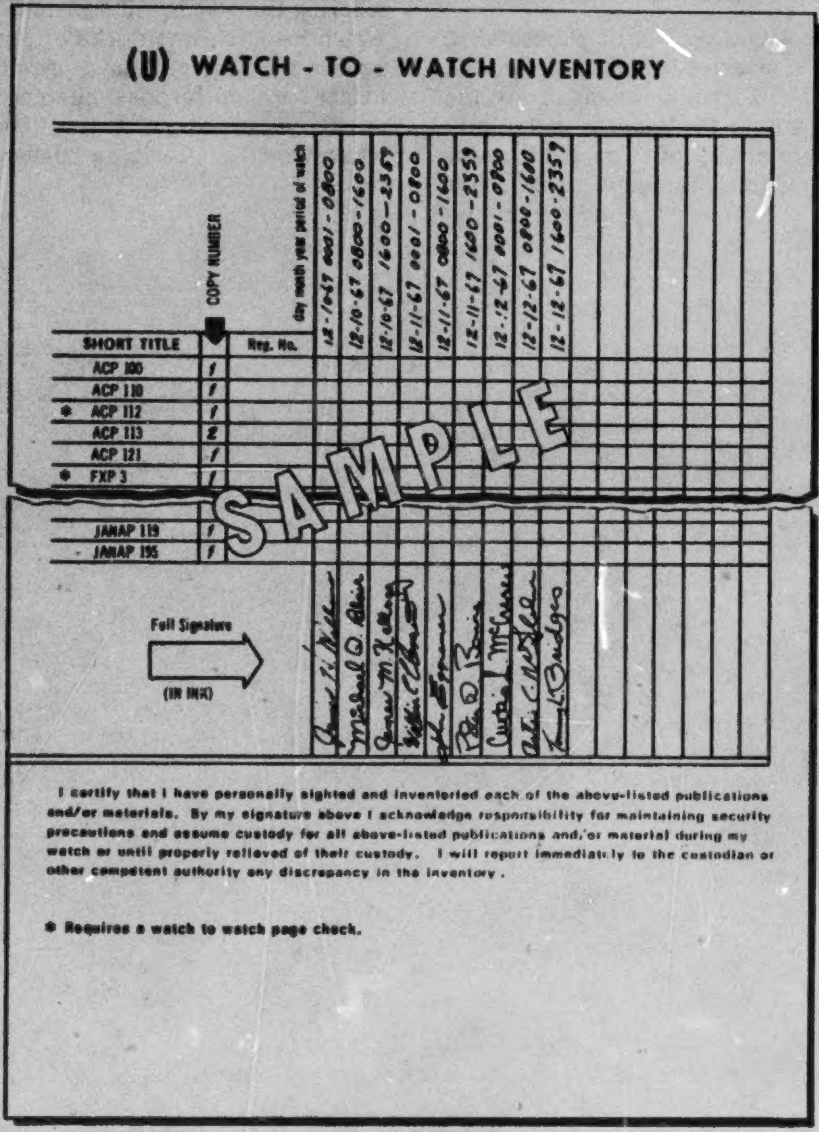
NOTE: Entry for commencement and cessation of sounding fog signals must always be made.

Personnel

Absentees

0800 Mustered the crew (at quarters) (at foul weather parade) (on stations) (at quarters for Captain's inspection). Absentees: (None) (No new absentees) (SA John Q. NEDOPS, USN, 000-00-0000, absent without authority from muster) (FN Roscoe BADEGG, USN, 000-00-0000, UA since 0700 this date).

NOTE: There is no legal distinction between absence over leave and absence without leave.



(U) WATCH - TO - WATCH INVENTORY

SHORT TITLE	COPY NUMBER	Reg. No.	day month year period of watch	12-10-67 0001-0800	12-10-67 0800-1600	12-10-67 1600-2359	12-11-67 0001-0800	12-11-67 0800-1600	12-11-67 1600-2359	12-12-67 0001-0800	12-12-67 0800-1600	12-12-67 1600-2359							
ACP 100	1																		
ACP 110	1																		
* ACP 112	1																		
ACP 113	2																		
ACP 121	1																		
* FXP 3	1																		
JANAP 119	1																		
JANAP 155	1																		
Full Signature (IN INK)																			

SAMPLE

I certify that I have personally sighted and inventoried each of the above-listed publications and/or materials. By my signature above I acknowledge responsibility for maintaining security precautions and assume custody for all above-listed publications and/or material during my watch or until properly relieved of their custody. I will report immediately to the custodian or other competent authority any discrepancy in the inventory.

* Requires a watch to watch page check.

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Figure 2-2.—Publications custody log.

All are logged as unauthorized absence or UA. In the case of a man's continued absence, the initial entry indicating absence or UA will suffice until the man returns, is declared a deserter, or is otherwise transferred or detached from the ship.

PUBLICATION CUSTODY

To provide position control of publications, a watch-to-watch inventory similar to the one shown in figure 2-2 should be used. At the change of each watch, the watches will jointly conduct a sight inventory of every publication. Some looseleaf publications require a page check at the change of the watch in addition to the sight inventory. These looseleaf publications will be specifically indicated on the watch-to-watch inventory. The signing of the watch-to-watch inventory by the relieving watch certifies that the publications were sighted, the required page checks were conducted, and the relieving watchstander is responsible for them. Any discrepancies noted will be resolved prior to relieving the watch. All signatures will be in ink. Watch-to-watch inventories of publications may be destroyed after 30 days, provided they are no longer required for local reference. If, on board ships, an inventory is not conducted on a watch-to-watch basis, a daily inventory is required.

CHAPTER 3

HONORS AND CEREMONIES

Since the days when the United States emerged as an independent nation, tradition has played an important role in the ceremonial functions of our Navy. At first, most of the honors and ceremonies rendered by our Navy were carried over from the British Navy. Before many years went by, however, the United States Navy began changing these carryover honors and ceremonies to conform to its own concept of ceremonial functions. As a result, the United States Navy now has a rigid set of rules covering all ceremonies.

All types and phases of ceremonial functions rendered by and on board naval vessels are presented in this chapter. Quartermasters must know what is required and also when, how, why, where, and by whom the honors and ceremonies are given.

PASSING HONORS

Passing honors are those honors, except gun salutes, rendered by ships and boats when ships, embarked officials, or officers pass (or are passed) close aboard. Close aboard means passing within 600 yards for ships and within 400 yards for boats. To ensure that appropriate honors are given, these distance limitations should be interpreted liberally.

Passing honors consist of sounding the command "Attention," followed by a hand salute by all persons in view on deck and not in ranks. Passing honors are exchanged between ships of the U.S. Navy, and between ships of the Navy and the Coast Guard, passing close aboard.

Table 3-1 prescribes the honors for a ship of the Navy when passing close aboard a ship or naval station displaying the flag of the officials indicated , and for naval stations (insofar as practicable) when a ship displaying such flag passes close aboard. These honors are acknowledged by returning the same honors.

Table 3-2 lists the honors to be rendered by a ship of the Navy being passed close aboard by a boat displaying the flag or pennant of a civil official or a naval officer.

FOREIGN DIGNITARIES AND WARSHIPS

The honors prescribed for the President of the United States are given by a ship of the Navy being passed close aboard by a ship or boat displaying the flag or standard of a foreign president, sovereign, or member of a reigning family. The foreign national anthem is played instead of the national anthem of the United States.

Passing honors are exchanged when foreign warships pass close aboard. The honors consist of parading the guard of the day, sounding "Attention," rendering the hand salute by all persons in view on deck, and playing the foreign national anthem.

RENDERING PASSING HONORS

The command "Attention" is sounded by the junior when the bow of one ship passes the bow or stern of the other vessel. If a senior is embarked in a boat, "Attention" is sounded before the boat is abreast or nearly abreast of the quarterdeck.

The guard, when required, shall "Present arms"; and all persons in view on deck shall salute. Music is played when required. The order "Carry on" is sounded when the prescribed honors are rendered and acknowledged.

Table 3-1.—Passing Honors Rendered by a Ship or a Naval Station

Official	Uniform	Ruffles and flourishes	Music	Guard	Remarks
President	As prescribed by senior officer present.	4	National Anthem	Full	Man rail, unless otherwise directed by senior officer present.
Secretary of State when special foreign representative of the President.	do	4	do	do	Crew at quarters.
Vice President	Of the day		Hail Columbia	do	Do.
Secretary of Defense, Deputy Secretary of Defense, or Secretary of the Navy, Director of Defense Research and Engineering.	do		National Anthem	do	Do.
An Assistant Secretary of Defense, Under Secretary or an Assistant Secretary of the Navy.	do		do	do	Do.

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Passing honors are not rendered after sunset nor before 0800 except when international courtesy requires. Passing honors are not exchanged between ships of the Navy when they are engaged in tactical evolutions outside port. The senior officer present may direct that passing honors be dispensed with in whole or in part.

Precedence of Shipboard Means of Announcing

There are a number of ways to call attention to ceremonies, events, departures, arrivals, etc. aboard a Navy ship. The preferred order of use is as follows:

1. Bugle
2. Whistle
3. Passing the word

Not more than one means should be used for a given event and the same means should be used throughout that event; e.g., "Attention to port" should not be announced by a whistle and followed by the same order given orally over the ship's loudspeaker. "Carry on" should not be announced using a different device than that used to announce "Attention."

Bugle and Whistle Signals

To standardize bugle and whistle signals when used for passing/side honors, the following are prescribed:

One Blast	Attention to starboard
Two Blasts	Attention to port
One Blast	Render salute
Two Blasts	Terminate salute, remain at attention
Three Blasts	Carry on

Table 3-2.—Passing Honors Rendered by a Ship Being Passed by a Boat

Official	Ruffles and flourishes	Music	Guard	Remarks
President	4	National Anthem	Full	"Attention" sounded, and salute by all persons in view on deck. If directed by the senior officer present, man rail.
Secretary of State when special foreign representative of the President.	4	do	do	"Attention" sounded, and salute by all persons in view on deck.
Vice President	4	Hail Columbia	—	Do.
Secretary of Defense, Deputy Secretary of Defense, Secretary of the Navy, Director of Defense Research and Engineering, an Assistant Secretary of Defense, Under Secretary or an Assistant Secretary of the Navy.	4	Admiral's March	do	Do.
Other Civil official entitled to honors on official visit.	—	—	—	Do.
Officer of an armed service	—	—	—	Do.

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HONORS FOR OFFICERS

The honors due officers of the Armed Forces are set forth in table 3-3. These honors are rendered by ships and stations on the occasion of an official visit. Ashore, the single gun salute (when prescribed) is given on arrival instead of on departure.

An officer departing for or returning from an official visit is rendered, by his flagship or command, the honors established for such a formal visit. Aboard his flagship, however, the uniform of the day normally is worn, and gun salutes are not fired.

Upon arrival or departure of a visiting Navy captain or commander (or officer of equivalent grade in other services) who is not a chief of staff, commanding officer, or whose command identity is not known to the officer of the deck, the words "Staff gangway" are substituted for the official title.

NOTE: The term "official visit" means a formal visit of courtesy requiring special honors and ceremonies. An informal visit of courtesy requiring no special ceremonies is a "call."

PROCEDURE FOR OFFICIAL VISIT

The honors specified for an official visit are rendered on arrival as follows:

1. When the rail is manned, men are spaced uniformly at the rail on each weather deck, facing outboard.
2. The command "Attention" is sounded as the visitor's boat or vehicle approaches the ship.
3. If a gun salute is prescribed on arrival, it is fired as the visitor approaches and still is clear of the side. The proper flag or pennant is broken on the first gun and hauled down on the last gun except when it is to be flown for the duration of the visit. Other ships firing a concurrent salute

Table 3-3.—Honors Required for Officers of the Armed Forces

Officer	Uniform	Gun Salute		Ruffles and flourishes	Music	Guard	Side Boys
		Arrival	Departure				
Chairman, Joint Chiefs of Staff	Full dress	19	19	4	General's or Admiral's march	Full	8
Chief of Staff, U.S. Army	Do	19	19	4	General's march	Do	8
Chief of Naval Operations	Do	19	19	4	Admiral's march	Do	8
Chief of Staff, U.S. Air Force	Do	19	19	4	General's march	Do	8
Commandant of the Marine Corps	Do	19	19	4	Admiral's march	Do	8
General of the Army	Do	19	19	4	General's march	Do	8
Fleet Admiral	Do	19	19	4	Admiral's march	Do	8
General of the Air Force	Do	19	19	4	General's march	Do	8
Generals	Do	17	17	4	do	Do	8
Admirals	Do	17	17	4	Admiral's march	Do	8
Naval or other Military Governor, commissioned as such by the President, within the area of his jurisdiction.	Do		17	4	General's or Admiral's march	Do	8
Vice Admiral or Lieutenant General	Do		15	3	do	Do	8
Rear Admiral or Major General	Do		13	2	do	Do	6
Commodore or Brigadier General	Do		11	1	do	Do	6
Captain, Commander, Colonel, or Lieutenant Colonel	Of the day					Of the day	4
Other Commissioned Officers	Do					Do	2

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also haul down, on the last gun, the flag or pennant displayed in honor of the visitor.

NOTE: If the ship visited is moored to the pier in such a position that it is impracticable to render the gun salute before arrival on board, the salute is rendered—provided local regulations do not forbid gun salutes—after the official arrives on board and the commanding officer assures himself that the dignitary and his party are moved to a position in the ship that is well clear of the saluting battery.

4. The boat or vehicle is piped as it comes alongside.

5. The visitor is piped over the side, and all persons on the quarterdeck salute and the guard presents arms until the termination of the pipe, flourishes, music, or gun salute, depending on which is rendered last.

6. If the gun salute is not prescribed on arrival, and a flag or pennant is to be displayed during the visit, it is broken at the start of the pipe.

7. The piping of the side, the ruffles and flourishes, and the music are executed in the order named. In the absence of a band, "To the Colors" is sounded on the bugle, in lieu of the national anthem, when required.

8. The visitor, if entitled to 11 guns or more, is invited to inspect the guard upon completion of the gun salute or such other honors as may be accorded him.

On departure, the honors prescribed for an official visit are as follows:

1. The rail is manned, if required.
2. The command "Attention" is sounded as the visitor arrives on the quarterdeck.
3. When the visitor is ready to leave the ship, the guard presents arms, all persons on the quarterdeck salute, and ruffles and flourishes, followed by music, are sounded. The visitor then is piped over the side. The salute and present arms terminate with the call. If no salute is fired, the flag or pennant displayed in honor of the visitor is hauled down.
4. The boat or vehicle is piped away from the side.
5. If a gun salute is directed upon departure, it is fired when the visitor is clear of the side. If a flag or pennant is displayed in honor of the visitor, it is hauled down with the last gun of the salute.

When possible, the same honors and ceremonies are rendered on the occasion of an official visit to a naval station.

SIDE HONORS

On the arrival and departure of civil officials and foreign officers, and of United States officers when directed by the senior officer present, the side is piped and the appropriate number of side boys paraded.

Side boys are not paraded on Sunday or between sunset and 0800 on other days. They are not paraded during meal hours of the crew, general drills and evolutions, nor periods of regular overhaul. As an exception to the foregoing rules, side boys may be paraded at any time during daylight hours in honor of civil officials or foreign officers.

Except for official visits and other formal occasions, side boys are not paraded in honor of officers of the armed services of the United States unless the senior officer present directs otherwise.

The side is piped when side boys are paraded but not at other times. When side boys are not ordered, the guard and band are not paraded in honor of the arrival or departure of an individual.

FLAG OFFICER OR UNIT COMMANDER ASSUMING OR RELIEVING COMMAND

When a flag officer or unit commander relieves a command or departs after being relieved, the same honors are rendered as for an official visit, subject to the regulations pertaining to gun salutes.

When assuming a command, an officer reads his orders to the assembled officers and crew. Immediately after reading his orders, his personal flag or command pennant is broken. Thereupon, the gun salute is fired, if required by Navy Regulations.

If the flag officer or unit commander is relieving another officer in command, the officer being relieved reads his orders to the assembled officers and crew. On completion thereof, or after the gun salute (if fired), his flag or command pennant is hauled down. The officer succeeding to command then reads his orders, after which his flag or command pennant is broken. The commission pennant is not displayed aboard ship if a personal flag or pennant is flying.

OFFICIAL INSPECTIONS

When a flag officer or a unit commander boards a ship of the Navy to make an official inspection, honors are rendered as for an official visit except that the uniform is prescribed by the inspecting officer. His flag or command pennant is broken upon his arrival and is hauled down on his departure. When his flag is on board the vessel being inspected, his personal flag is hauled down on board his flagship. If the vessel being inspected is his flagship, his flag remains flying. Insofar as practicable and appropriate, the same provisions apply when a flag officer in command ashore makes an official inspection of a unit of his command.

HONORS FOR CIVIL OFFICIALS AND FOREIGN DIGNITARIES

A ship or station must render honors to civil officials of the United States as indicated in table 3-4. Foreign dignitaries are honored as shown in table 3-5. As with honors for officers of the Armed Forces, ashore the single gun salute (when prescribed) is given on arrival instead of on departure.

When a civil official of the United States takes passage officially in a ship of the Navy, he

Table 3-4.—Honors for Civil Officials of the United States

HONORS AND CEREMONIES[5]

Official	Uniform	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys[4]	Crew[4]	Within what limits	Flag	
		Arrival	Departure							What	Where
The President	Full dress	21	21	4	National Anthem[1]	Full	8	Man rail		President's	Main Truck
Former Presidents	do		21	4	Admiral's March	do	8	Quarters		National	do
Vice President	do		19	4	Hail Columbia	do	8	Quarters		Vice President's	do
Governor of a State	do		19	4	Admiral's March	do	8		Area under his jurisdiction	National	Fore Truck
Speaker of the House of Representatives	do		19	4	do	do	8			do	do
The Chief Justice of the United States	do		19	4	do	do	8			do	do
Ambassador, High Commissioner, or special diplomatic representative whose credentials give him authority equal to or greater than that of an Ambassador	do		19	4	National Anthem	do	8		Nation or nations to which accredited	do	do
Secretary of State	do		19	4	do	do	8			do	do
U.S. Representative to the U.N.	do		19	4	Admiral's March	do	8			do	do
Associate Justices of the Supreme Court	do		19	4	do	do	8			do	do
Secretary of Defense	do	19	19	4	Honor's March	do	8	Quarters		Secretary's	Main Truck

See foot notes at bottom of table.

Table 3-4.—Honors for Civil Officials of the United States

HONORS AND CEREMONIES[5]

Uniform	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys[4]	Crew[4]	Within what limits	Flag		
	Arrival	Departure							What	Where	During
Full dress	21	21	4	National Anthem[1]	Full	8	Man rail		President's	Main Truck	Visit
do		21	4	Admiral's March	do	8	Quarters		National	do	Salute
do		19	4	Hail Columbia	do	8	Quarters		Vice President's	do	Visit
do		19	4	Admiral's March	do	8		Area under his jurisdiction	National	Fore Truck	Salute
do		19	4	do	do	8			do	do	do
do		19	4	do	do	8			do	do	do
do		19	4	National Anthem	do	8		Nation or nations to which accredited	do	do	do
do		19	4	do	do	8			do	do	do
do		19	4	Admiral's March	do	8			do	do	do
do		19	4	do	do	8			do	do	do
do	19	19	4	Honor's March	do	8	Quarters		Secretary's	Main Truck	Visit

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Table 3-4.—Honors for Civil Officials of the United States (continued)

HONORS AND CEREMONIES[5]

Official	Uniform	Gun Salute			Music	Guard	Sideboys [4]	Crew [4]	Within what limits	Flag		
		Arrival	Departure	Ruffles and flourishes						What	Where	During
Cabinet Officers (other than Secretaries of State and Defense)[2]	Full dress		19	4	Admiral's March	do	8			National	Fore Truck	S
President Pro Tempore of Senate	do		19	4	do	do	8			do	do	
United States Senators	do		19	4	do	do	8			do	do	
Governor of a State of the United States	do		19	4	do	do	8		Out of jurisdiction	do	do	
Members of the House of Representatives	do		19	4	do	do	8			do	do	
Deputy Secretary of Defense	do	19	19	4	Honor's[3] March	do	8	Quarters		Deputy Secretary's	Main Truck	
Secretary of the Army	do	19	19	4	do	do	8			National	Fore Truck	
Secretary of the Navy	do	19	19	4	do	do	8	Quarters		Secretary's	Main Truck	
Secretary of the Air Force	do	19	19	4	do	do	8			National	Fore Truck	
Director of Defense Research and Engineering	do	19	19	4	do	do	8	Quarters		Director's	Main Truck	
Assistant Secretaries of Defense and General Counsel of DOD	do	17	17	4	do	do	8	Quarters		Assistant Secretary's	do	
Under Secretary of the Army	do	17	17	4	do	do	8			National	Fore Truck	
Under Secretary of the Navy	do	17	17	4	do	do	8	Quarters		Under Secretary's	Main Truck	

See foot notes at bottom of table.

Table 3-4.—Honors for Civil Officials of the United States (continued)

HONORS AND CEREMONIES[5]										
Gun Salute								Flag		
Arrival	Departure	Ruffles and flourishes	Music	Guard	Sideboys[4]	Crew[4]	Within what limits	What	Where	During
	19	4	Admiral's March	do	8			National	Fore Truck	Salute
	19	4	do	do	8			do	do	do
	19	4	do	do	8			do	do	do
	19	4	do	do	8		Out of jurisdiction	do	do	do
	19	4	do	do	8			do	do	do
19	19	4	Honor's[3] March	do	8	Quarters		Deputy Secretary's	Main Truck	Visit
19	19	4	do	do	8			National	Fore Truck	Salute
19	19	4	do	do	8	Quarters		Secretary's	Main Truck	Visit
19	19	4	do	do	8			National	Fore Truck	Salute
19	19	4	do	do	8	Quarters		Director's	Main Truck	Visit
17	17	4	do	do	8	Quarters		Assistant Secretary's	do	do
17	17	4	do	do	8			National	Fore Truck	Salute
17	17	4	do	do	8	Quarters		Under Secretary's	Main Truck	Visit

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Table 3-4.—Honors for Civil Officials of the United States (continued)

HONORS AND CEREMONIES [5]

Official	Uniform	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys[4]	Crew[4]	Within what limits	Flag		
		Arrival	Departure							What	Where	Du
Under Secretary of the Air Force	do	17	17	4	do	do	8			National	Fore Truck	S
Assistant Secretaries of the Army	do	17	17	4	do	do	8			do	do	
Assistant Secretaries of the Navy	Full dress	17	17	4	Honor's[3] March	Full	8	Quarters		Assistant Secretary's	Main Truck	V
Assistant Secretaries of the Air Force	do	17	17	4	do	do	8			National	Fore Truck	S
Governor General or Governor of a Commonwealth or Possession of the United States, or area under United States jurisdiction	do		17	4	Admiral's March	do	8		Area under his jurisdiction	do	do	
Other Under Secretaries of Cabinet, the Deputy Attorney General	do		17	4	do	do	8			do	do	
Envoy Extraordinary and Minister Plenipotentiary	do		15	3	do	do	8		Nation to which accredited	do	do	
Minister Resident	do		13	2	do	do	6		do	do	do	
Charge d'Affaires	do		11	1	do	do	6		do	do	do	
Career Minister, or Counselor of Embassy or Legation	do			1	do	do	6		do			
Consul General; or Consul or Vice Consul or Deputy Consul General when in charge of a Consulate General	do		11	1	do	do	6		District to which assigned	do	do	

See foot notes at bottom of table.

Table 3-4.—Honors for Civil Officials of the United States (continued)

HONORS AND CEREMONIES[5]

rm	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys[4]	Crew[4]	Within what limits	Flag		
	Arrival	Departure							What	Where	During
	17	17	4	do	do	8			National	Fore Truck	Salute
	17	17	4	do	do	8			do	do	do
dress	17	17	4	Honor's[3] March	Full	8	Quarters		Assistant Secretary's	Main Truck	Visit
o	17	17	4	do	do	8			National	Fore Truck	Salute
o		17	4	Admiral's March	do	8		Area under his jurisdiction	do	do	do
		17	4	do	do	8			do	do	do
		15	3	do	do	8		Nation to which accredited	do	do	do
		13	2	do	do	6		do	do	do	do
		11	1	do	do	6		do	do	do	do
			1	do	do	6		do			
		11	1	do	do	6		District to which assigned	do	do	do

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Table 3-4.—Honors for Civil Officials of the United States (continued)

HONORS AND CEREMONIES [5]

Official	Uniform	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys [4]	Crew [4]	Within what limits	Flag		
		Arrival	Departure							What	Where	D
First Secretary of Embassy or Legation	Of the day					Of the day	4		Nation to which accredited			
Consul; or Vice Consul when in charge of a Consulate	do		7			do	4		District to which assigned	do	do	
Mayor of an incorporated city	do					do	4		Within limits of mayoralty			
Second or Third Secretary of Embassy or Legation	do						2		Nation to which accredited			
Vice Consul when only representative of United States, and not in charge of a Consulate General or Consulate	Of the day		5			Of the day	2		District to	National	Fore Truck	
Consular agent when only representative of the United States	do						2	do				

[1] See Article regarding required honors to President

[2] In the order of precedence as follows:
- Secretary of State
- Secretary of the Treasury
- Secretary of Defense
- Attorney General
- Secretary of the Interior
- Secretary of Agriculture
- Secretary of Commerce
- Secretary of Labor
- Secretary of Health, Education, and Welfare
- Secretary of Housing and Urban Development
- Secretary of Transportation

[3] 32-bar melody in the trio of "Stars and Stripes Forever"

[4] Not appropriate on shore installations

[5] Not to be construed as a precedence list

Table 3-4.—Honors for Civil Officials of the United States (continued)

HONORS AND CEREMONIES[5]

form	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys[4]	Crew[4]	Within what limits	Flag		
	rrival	Departure							What	Where	During
e day					Of the day	4		Nation to which accredited			
o		7			do	4		District to which assigned	do	do	do
o					do	4		Within limits of mayoralty			
o						2		Nation to which accredited			
e day		5			Of the day	2		District to	National	Fore Truck	Salute
o						2	do				

s to President

s:

[3] 32-bar melody in the trio of "Stars and Stripes Forever"

[4] Not appropriate on shore installations

[5] Not to be construed as a precedence list

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Table 3-5.—Honors for Foreign Officials and Officers

Official or Officer	Uniform	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys[1]	Crew[1]	Flag		
		Arrival	Departure						What	Where	During
President or Sovereign	Full dress	21	21	4	Foreign National Anthem	Full	8	Man Rail	Foreign ensign	Main Truck	Visit
Member of reigning royal family	do	21	21	4	do	do	8	do	do	do	Salute
Prime Minister or other cabinet officer.	do		19	4	Admiral's March	do	8		do	Fore Truck	do
Officer of armed forces, diplomatic or consular representative in country to which accredited, or other distinguished official.	Civil officials: Honors for official of the United States of comparable position. For example, foreign civil officials, occupying positions comparable to U.S. Department of Defense civil officials, shall receive equivalent honors. Officers of Armed Forces: Honors as for officer of the United States of the same grade, except, that equivalent honors shall be rendered to foreign officers who occupy a position comparable to Chairman JCS, CNO, Chief of Staff Army, Chief of Staff Air Force, or CMC. Honors as prescribed by the senior officer present; such honors normally shall be those accorded the foreign official when visiting officially a ship of his own nation, but a gun salute, if prescribed, shall not exceed 19 guns										

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[1] Not appropriate on shore installations

Table 3-5.—Honors for Foreign Officials and Officers

	Gun Salute		Ruffles and flourishes	Music	Guard	Sideboys[1]	Crew[1]	Flag		
	Arrival	Departure						What	Where	During
ss	21	21	4	Foreign National Anthem	Full	8	Man Rail	Foreign ensign	Main Truck	Visit
	21	21	4	do	do	8	do	do	do	Salute
		19	4	Admiral's March	do	8		do	Fore Truck	do

icials: Honors for official of the United States of comparable position.
mple, foreign civil officials, occupying positions comparable to U.S.
ent of Defense civil officials, shall receive equivalent honors.
of Armed Forces: Honors as for officer of the United States of the same
xcept, that equivalent honors shall be rendered to foreign officers who
a position comparable to Chairman JCS, CNO, Chief of Staff Army, Chief
Air Force, or CMC.
as prescribed by the senior officer present; such honors normally shall be
corded the foreign official when visiting officially a ship of his own nation,
n salute, if prescribed, shall not exceed 19 guns

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tions

69.129

is rendered the same honors on embarking and disembarking as prescribed for an official visit. Additionally, if he is entitled to a gun salute, it is fired when he disembarks in a port of the foreign nation to which he is accredited.

FLAG DISPLAYS

Preceding sections of this chapter dealt with the honors and ceremonies for civil officials and officers of the United States and foreign countries. Another of your duties as Quartermaster is identifying flags flown by ships of the United States Navy as well as the national and merchant flags of the principal maritime nations. The remainder of this chapter discusses and illustrates these flags and some of the ceremonies that pertain to them.

NATIONAL ENSIGN

Since June 14, 1777, the ensign (see figure 3-1) has served as a symbol of our country's greatness. Because it represents our country, we owe it every respect and honor to which it is entitled.

During the ceremony of hoisting and lowering the national ensign, or when the ensign is passing in a parade or review, all persons who are not part of a military formation should stand, face the colors, and come to attention. Armed services personnel in uniform render the hand salute. A man in civilian dress should remove his hat with the right hand and hold it at a point on the left shoulder so that the hand is over the heart.

Personnel in civilian dress, but hatless, should stand at attention with the right hand over the heart. If the ensign is carried in a moving column, the hand salute should be made as the flag passes.

When the ensign is displayed as the national anthem is being played, military personnel should salute while facing the ensign. The same salute should be executed, facing the music, if the ensign is not visible to the person rendering the salute.

When the ensign is carried in a procession with another flag or with several flags, the ensign should be on the marching right of a single line. Alternatively, it should be by itself in front of the center of the line in which the other flags are carried.

When a number of flags, including the ensign, are flown from adjacent poles or masts, the ensign is hoisted first and lowered last. No other flag should be placed to the right of the ensign; that is to the flag's right.

If the ensigns of two or more nations are displayed, they are flown at the same height from separate masts and should be approximately equal in size. International custom forbids flying one nation's ensign above that of another nation.

Flags flown from fixed masts or flagpoles are placed at half-mast to indicate mourning. Because the ensign cannot be placed at half-mast on a small portable staff, such as that carried in a parade, mourning is signified by attaching two black crepe streamers to the spearhead. Crepe streamers are used only when ordered by the President. When the ensign is to be flown at half-mast, it first should be hoisted to the peak for an instant and then lowered to the half-mast position. Before the colors are lowered for the day, they should be raised again to the peak.

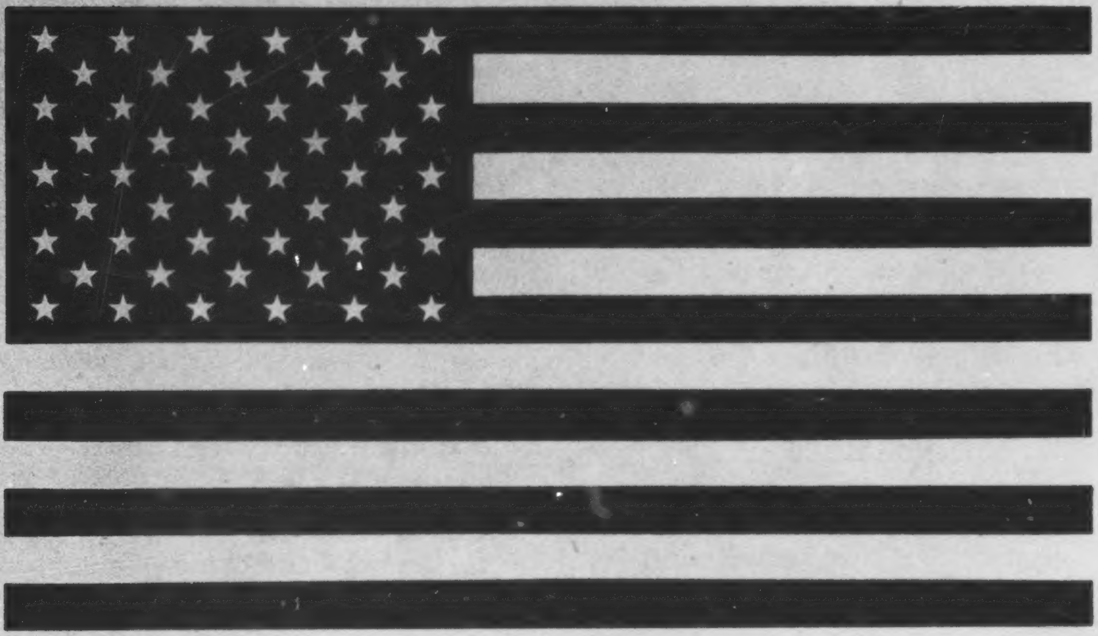
Aboard Ship

The national ensign on a Navy ship at anchor is hoisted at 0800 on the flagstaff. The union jack is hoisted on the jackstaff. Both flags are kept flying until sunset.

If two or more vessels are in company in port, the senior officer present signals at 0745 to specify the size of colors to display for the day. If his signal is made after 0800, the ensign is hauled down upon execution of the signal, and an ensign of the prescribed size is hoisted.

When a naval vessel gets underway and there is enough light for the ensign to be seen, it should be hoisted even though it is earlier than 0800 or after sunset. When falling in with other ships or when near land, the ensign also should be displayed.

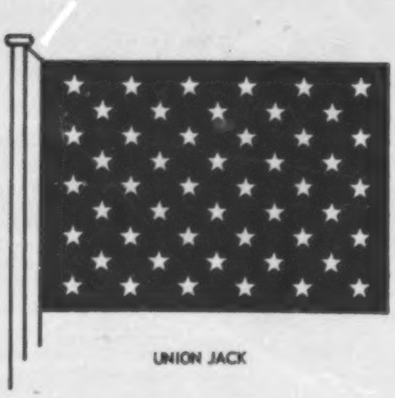
Naval shore stations follow the same rule as ships concerning showing the national ensign from 0800 to sunset. The base commander designates where the ensign is to be displayed.



NATIONAL FLAG
ENSIGN AND MERCHANT FLAG

DIMENSIONS

HOIST (WIDTH) OF FLAG	1.0
FLY (LENGTH) OF FLAG	1.9
HOIST (WIDTH) OF UNION	7/13
FLY (LENGTH) OF UNION	.76
WIDTH OF EACH STRIPE	1/13



UNION JACK

C17.69

Figure 3-1.—The United States national ensign and the union jack.

On a Navy ship underway, the ensign is flown from the gaff, which is a spar extending outward at an angle from the mainmast.

If a Navy ship enters a foreign port during the night, she hoists her ensign at daylight for a short time to enable port authorities to distinguish her nationality. It is customary for other ships in port to show their colors in return.

In wartime, no action is commenced nor is a battle fought without displaying the national ensign.

Displaying National Ensign in Boats

The national ensign is displayed in waterborne boats belonging to naval vessels under the following circumstances:

1. Underway during daylight in a foreign port.
2. When ships are required to be dressed or full-dressed.
3. Going alongside a foreign vessel.
4. When an officer or official is embarked on an official occasion.
5. When a flag officer or general officer, a unit commander, a commanding officer, or a chief of staff, in uniform, is embarked in a boat of his command or in one assigned for his personal use.
6. At such other times as may be prescribed by the senior officer present.

Answering a Dip

When a vessel of any nation formally recognized by the United States salutes a ship of our Navy by dipping her ensign, the salute is returned by the U.S. Navy ship dip for dip. If the original salute is given before 0800, after sunset, or at any other time when the ensign is not displayed, the Navy ship hoists her colors, returns the salute, then hauls down the colors after a short interval. An ensign displayed at half-mast is hoisted to the peak or truck before a dip is answered. Ships of the U.S. Navy never dip the national ensign unless in return for such compliment.

It should be noted that the United States may recognize a government although it may not have or may have broken diplomatic relations with that government. The following governments are not now (June 1974) formally recognized by the United States and are not entitled to the dip:

Albania
Communist China
East Germany
Mongolia
North Korea
North Vietnam

Figure 3-2 shows the flags of nations NOT formally recognized by the United States. Since Mongolia is landlocked and no merchant fleet is registered, the chance of seeing their flag on a ship is small. (Refer to explanatory note in figure 3-3.)

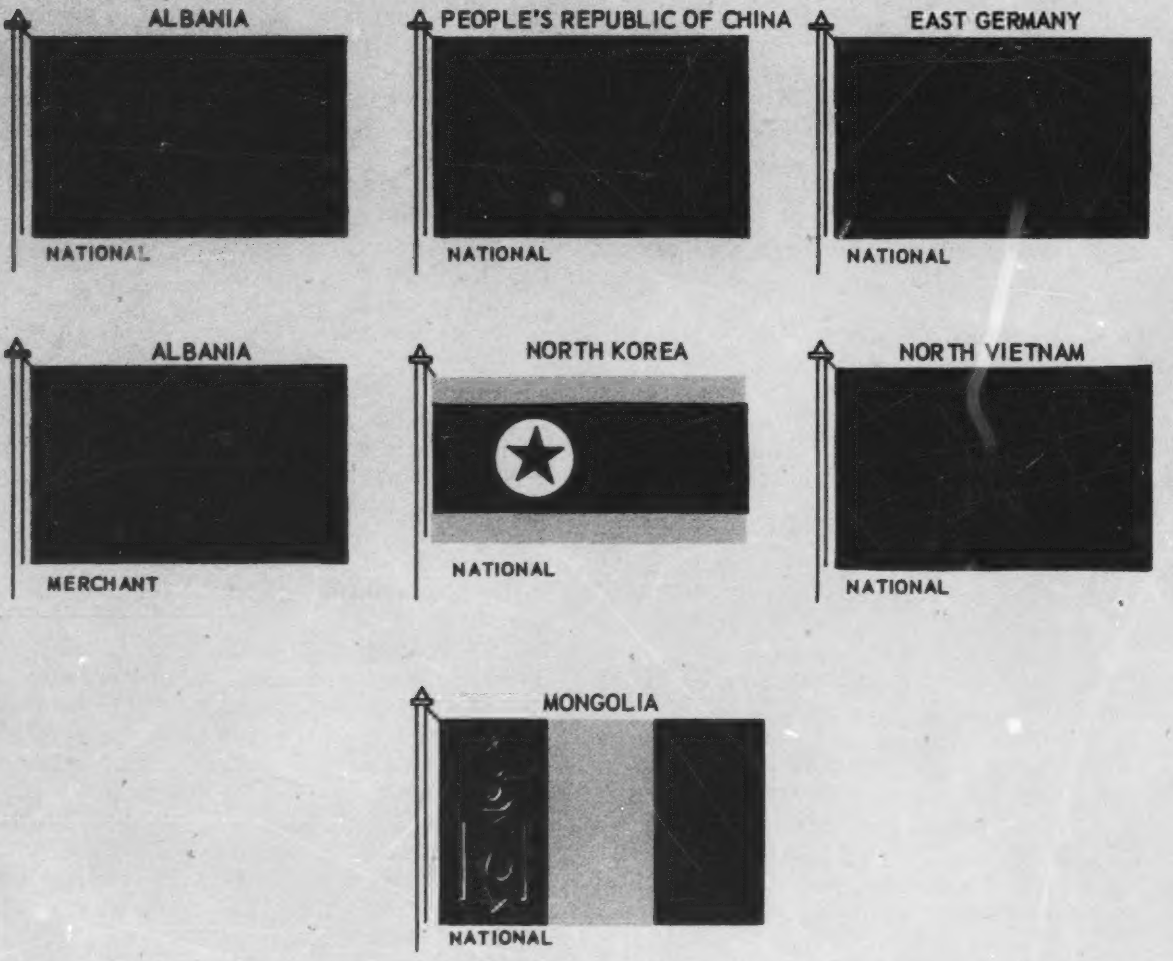
National Ensign During Gun Salutes

While firing a salute in honor of a United States national anniversary, as on Washington's Birthday or the Fourth of July, the national ensign is displayed at the main. It also is flown at the main during a 21-gun salute honoring a United States civil official unless the ship is displaying the personal flag of that official. During a salute to any other United States civil official, except by a ship displaying the personal flag of the official, the national ensign is displayed from the main or the fore; it also is displayed from the gaff of the flagstaff.

Half-Masting Ensign

The custom of flying the ensign at half-mast is observed as a tribute to the dead. The Navy has specific rules for all occasions of half-masting the ensign. They are as follows:

1. Whenever the ensign is to be half-masted, it first is raised to the peak (closed up) and then is lowered to the half-mast position. The same procedure is used when lowering the ensign. It first must be raised to the peak and then lowered.


ALBANIA
NATIONAL
PEOPLE'S REPUBLIC OF CHINA
NATIONAL
EAST GERMANY
NATIONAL
ALBANIA
MERCHANT
NORTH KOREA
NATIONAL
NORTH VIETNAM
NATIONAL
MONGOLIA
NATIONAL

C101.37

Figure 3-2.—Flags of nations not formally recognized by the United States.

2. On Memorial Day, the ensign is flown at half-mast from 0800 until completion of the 21-gun salute, fired at 1200, or until 1220 if no salute is fired.

3. Ships underway and in port are required to half-mast the national ensign in accordance with the appropriate articles of the U.S. Navy Regulations relating to such procedure.

During burial at sea, the ensign is at half-mast from the beginning of the funeral service until the body is committed to the deep. A longer period for displaying the ensign at half-mast may be prescribed, according to circumstances, by the senior officer present. Boats participating in a funeral procession also fly the national ensign at half-mast.

MISCELLANEOUS FLAGS AND PENNANTS

Miscellaneous flags and pennants authorized to be displayed, as circumstances dictate, are the

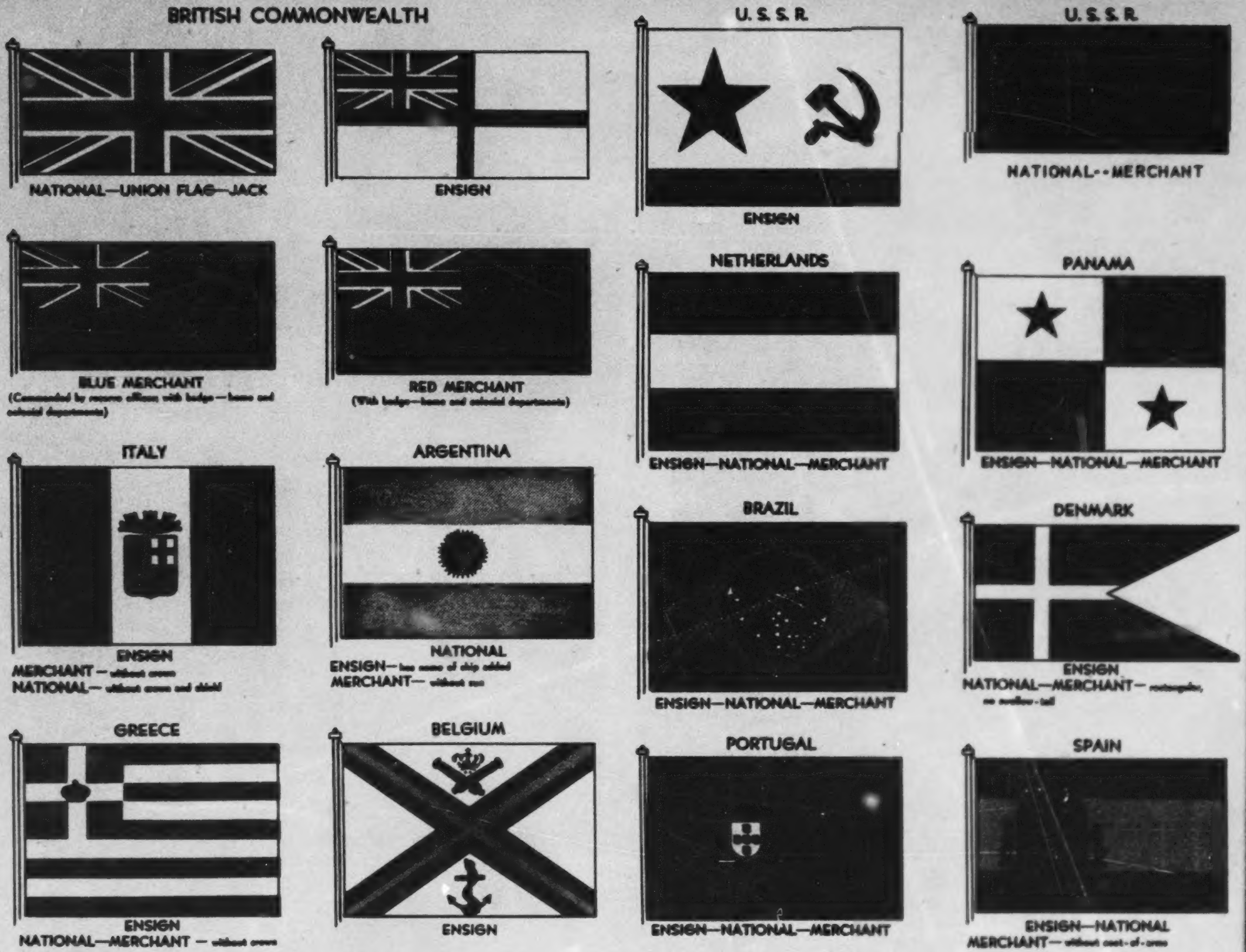

BRITISH COMMONWEALTH
NATIONAL—UNION FLAG—JACK
ENSIGN
U. S. S. R.
ENSIGN
U. S. S. R.
NATIONAL--MERCHANT
BLUE MERCHANT
(Commanded by reserve officers with badge—home and colonial departments)
RED MERCHANT
(With badge—home and colonial departments)
NETHERLANDS
ENSIGN—NATIONAL—MERCHANT
PANAMA
ENSIGN—NATIONAL—MERCHANT
ITALY
ENSIGN
MERCHANT—without crown
NATIONAL—without crown and shield
ARGENTINA
NATIONAL
ENSIGN—has name of ship added
MERCHANT—without sun
BRAZIL
ENSIGN—NATIONAL—MERCHANT
DENMARK
ENSIGN
NATIONAL—MERCHANT—rectangular, no swallow-tail
GREECE
ENSIGN
NATIONAL—MERCHANT — without crown
BELGIUM
ENSIGN
PORTUGAL
ENSIGN—NATIONAL—MERCHANT
SPAIN
ENSIGN—NATIONAL
MERCHANT—without coat-of-arms

Figure 3-3.—Flags of some of the leading maritime nations.

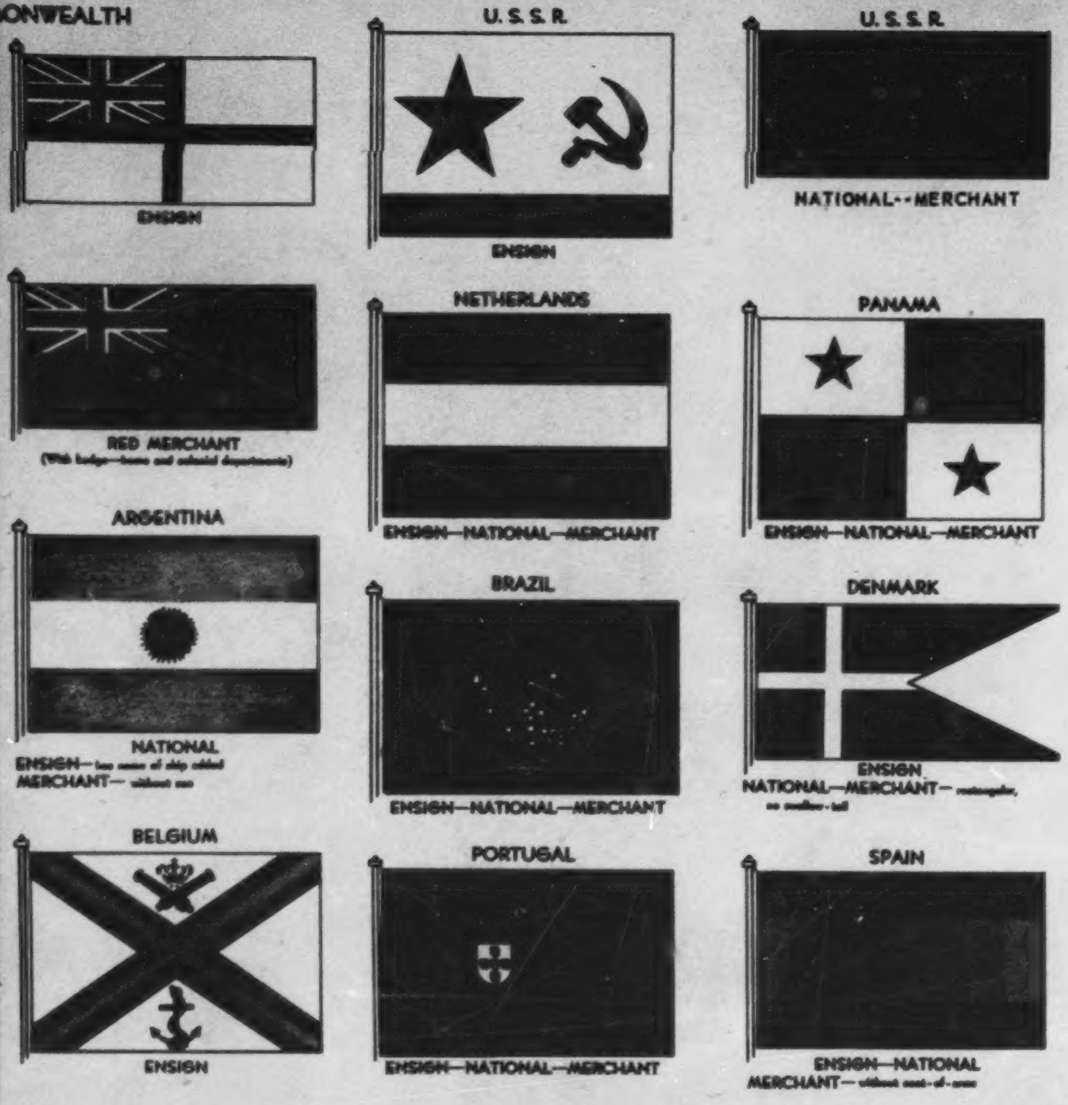
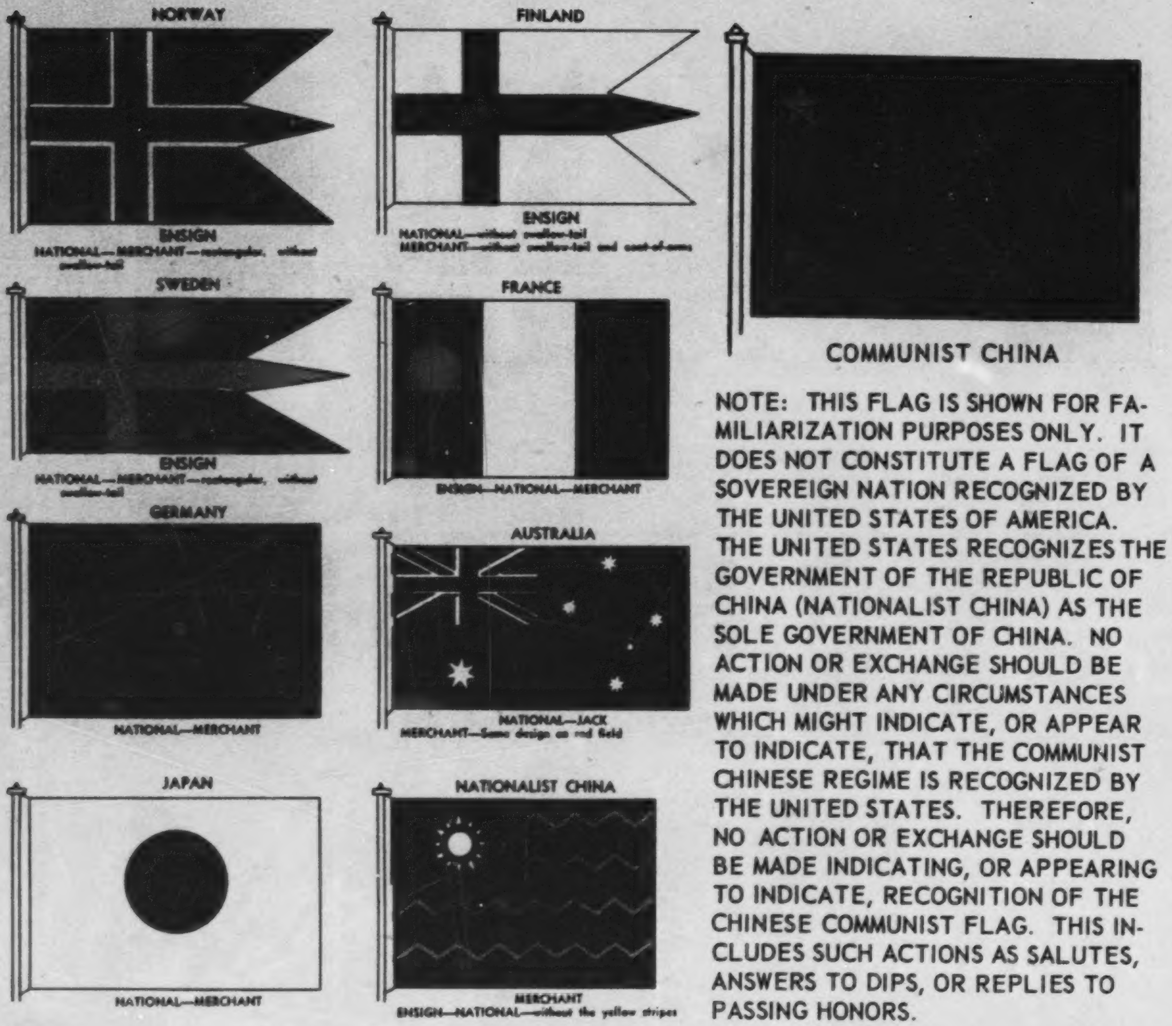

ONWEALTH
ENSIGN
RED MERCHANT
(With badge—home and colonial departments)
ARGENTINA
NATIONAL
ENSIGN—has name of ship added
MERCHANT— without sun
BELGIUM
ENSIGN
U. S. S. R.
ENSIGN
NETHERLANDS
ENSIGN—NATIONAL—MERCHANT
BRAZIL
ENSIGN—NATIONAL—MERCHANT
PORTUGAL
ENSIGN—NATIONAL—MERCHANT
U. S. S. R.
NATIONAL--MERCHANT
PANAMA
ENSIGN—NATIONAL—MERCHANT
DENMARK
ENSIGN
NATIONAL—MERCHANT— rectangular, no swallow-tail
SPAIN
ENSIGN—NATIONAL
MERCHANT— without coat-of-arms

Figure 3-3.—Flags of some of the leading maritime nations. C69.6.1


NORWAY
ENSIGN
NATIONAL—MERCHANT—rectangular, without swallow-tail
FINLAND
ENSIGN
NATIONAL—without swallow-tail
MERCHANT—without swallow-tail and coat-of-arms
SWEDEN
ENSIGN
NATIONAL—MERCHANT—rectangular, without swallow-tail
FRANCE
ENSIGN—NATIONAL—MERCHANT
GERMANY
NATIONAL—MERCHANT
AUSTRALIA
NATIONAL—JACK
MERCHANT—Same design on red field
JAPAN
NATIONAL—MERCHANT
NATIONALIST CHINA
MERCHANT
ENSIGN—NATIONAL—without the yellow stripes
COMMUNIST CHINA

NOTE: THIS FLAG IS SHOWN FOR FAMILIARIZATION PURPOSES ONLY. IT DOES NOT CONSTITUTE A FLAG OF A SOVEREIGN NATION RECOGNIZED BY THE UNITED STATES OF AMERICA. THE UNITED STATES RECOGNIZES THE GOVERNMENT OF THE REPUBLIC OF CHINA (NATIONALIST CHINA) AS THE SOLE GOVERNMENT OF CHINA. NO ACTION OR EXCHANGE SHOULD BE MADE UNDER ANY CIRCUMSTANCES WHICH MIGHT INDICATE, OR APPEAR TO INDICATE, THAT THE COMMUNIST CHINESE REGIME IS RECOGNIZED BY THE UNITED STATES. THEREFORE, NO ACTION OR EXCHANGE SHOULD BE MADE INDICATING, OR APPEARING TO INDICATE, RECOGNITION OF THE CHINESE COMMUNIST FLAG. THIS INCLUDES SUCH ACTIONS AS SALUTES, ANSWERS TO DIPS, OR REPLIES TO PASSING HONORS.

C69.6.1

Figure 3-3.—Flags of some of the leading maritime nations (continued).

(1) union jack; (2) commision pennants; (3) U.S. Navy flag; (4) U.S. Navy infantry battalion flag; (5) Red Cross flag; (6) church pennant; (7) CNO flag; (8) personal flags of Navy flag officers; (9) personal flags and pennants in boats and automobiles; (10) personal flags of staff corps officers; (11) broad command and burgee command pennants; (12) United Nations flag; (13) special flags of U.S. civil officials. The miscellaneous flags and pennants are described individually in ensuing topics.

Union Jack

The union jack is a replica of the blue, star-studded field in the corner of the national ensign. (Refer to figure 3-1.) It symbolizes the union of the states of the United States. Each star represents a state but not a particular state.

When a naval ship is at anchor, the union jack is flown from the jackstaff, in the bow of the ship, from 0800 to sunset. In addition to flying from the jackstaff, the union jack is hoisted also at the yardarm to indicate that a general court-martial or a court of inquiry is in session.

The union jack is flown in boats as follows:

1. When a diplomatic official of the United States of or above the rank of Charge d'affaires pays an official visit afloat in a boat of the U.S. Navy.

2. By a governor general or governor commissioned as such by the President, when embarked in a boat in his official capacity, and within the area under his jurisdiction (the Governor of the Virgin Islands, for instance).

When displayed from the jackstaff, the union jack is half-masted if the national ensign is half-masted. The union jack is not dipped when the national ensign is dipped.

The union jack is issued in several sizes; but, when flown at the jackstaff, it must be the same size as the union of the ensign flown at the flagstaff.

Commission Pennant

Every Navy ship in commission flies the commission pennant except when it is replaced by a personal flag, command pennant, or Red Cross flag. The commission pennant (figure 3-4) is flown at the after truck of a naval vessel or, if a mastless ship, at the highest and most conspicuous point of hoist. It also is flown from the bow of a boat when a commanding officer, not entitled to a personal flag, is embarked on an official visit.

The commission pennant is not a personal flag, but sometimes it is regarded as the personal symbol of the commanding officer. Along with the ensign and union jack, it is half-masted upon the death of the commanding officer of a ship.

U.S. Navy Flag

Before 1959, the U.S. Navy had not adopted an official flag. Until then, the U.S. Navy infantry battalion flag and, on rare occasions, the union jack were used semi-officially to represent the Navy. The flag shown in figure 3-5 fulfills the requirement for an official flag to represent the Navy on a wide variety of ceremonial, parade, and display occasions.

Red Cross Flag

Hospital ships fly at the main truck the Red Cross flag (figure 3-4) instead of the commission pennant. Boats engaged in sanitary service, also hospital boats of landing parties, fly the Red Cross flag from a staff in the bow.

Church Pennant

The church pennant is the only flag ever flown over the national ensign at the same point of hoist. It is displayed only during church services conducted by a chaplain on board vessels of the Navy. (See figure 3-4.)

CNO Flag

The Chief of Naval Operations flag (figure 3-4) is a blue and white rectangle, divided diagonally. In its center is the official seal of the Chief of Naval Operations–an eagle clutching an anchor and surrounded by a chain of 50 gold links. The CNO flag is displayed in the same manner as required for displaying flags of flag officers.

Personal Flags of Navy Flag Officers

When a flag officer of the Navy–a commodore, rear admiral, vice admiral, or admiral–assumes command of a fleet or a unit of a fleet, his personal flag (figure 3-4) is hoisted and kept flying until he turns over his command to his successor. If he is absent from his command for period exceeding 72 hours, his flag is hauled down.

A flag officer's flag never is displayed simultaneously from more than one ship. It is flown at the main truck by the ship he is aboard.

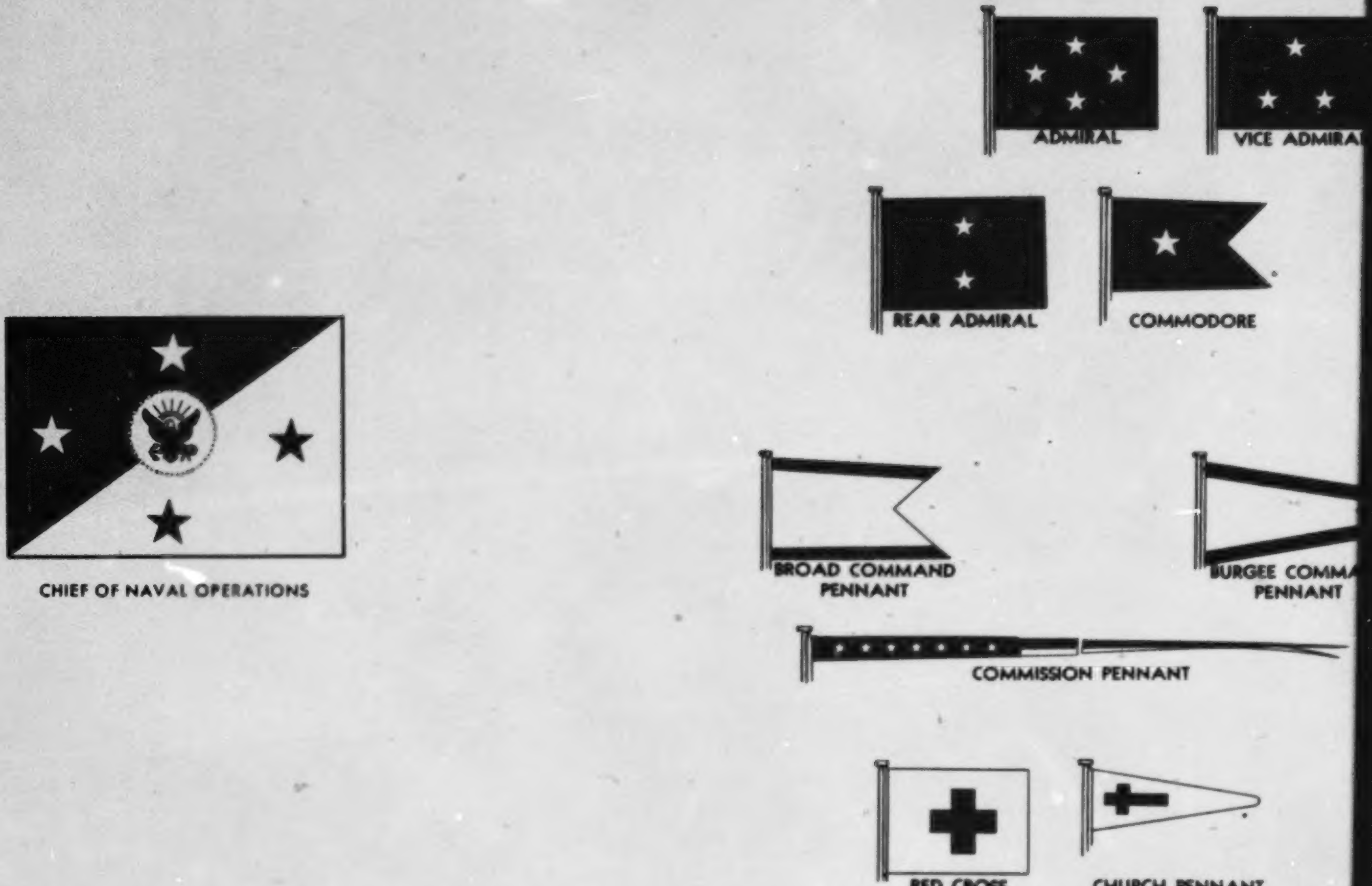

ADMIRAL
VICE ADMIRA
REAR ADMIRAL
COMMODORE
CHIEF OF NAVAL OPERATIONS
BROAD COMMAND PENNANT
URGEE COMM PENNANT
COMMISSION PENNANT
RED CROSS
CHURCH PENNANT
C1

Figure 3-4.—Personal, command, and miscellaneous flags and pennants.

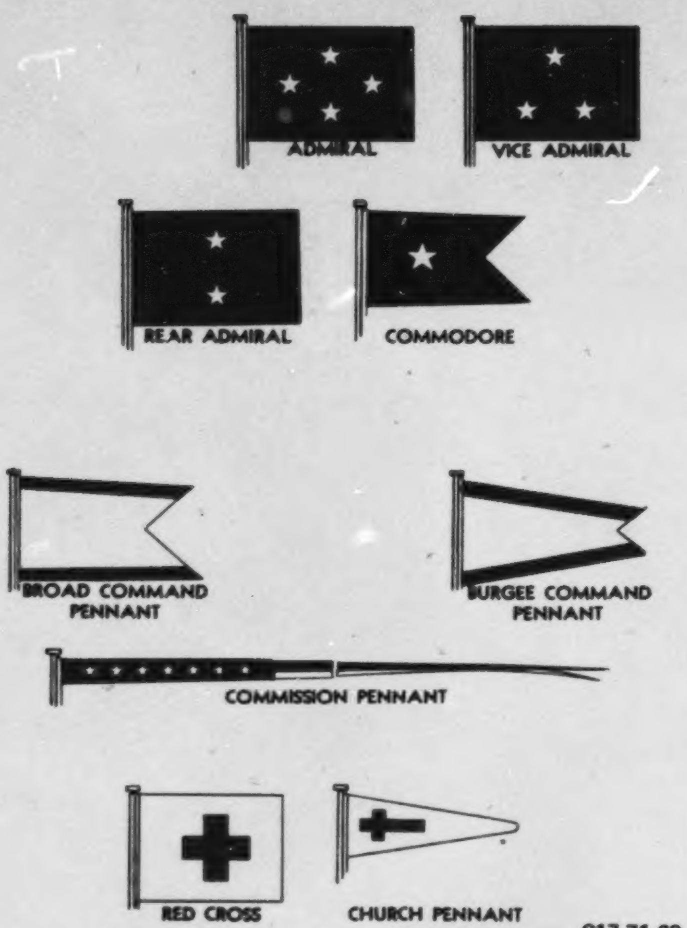
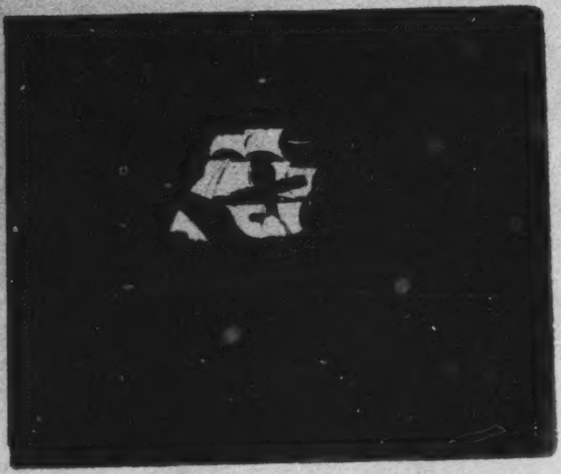

ADMIRAL
VICE ADMIRAL
REAR ADMIRAL
COMMODORE
BROAD COMMAND PENNANT
BURGEE COMMAND PENNANT
COMMISSION PENNANT
RED CROSS
CHURCH PENNANT
C17.71.69

Figure 3-4.—Personal, command, and miscellaneous flags and pennants.



C69.2

Figure 3-5.–The United States Navy flag.

Normally, no personal flag or pennant is shown at the same masthead with the national ensign. When a double display is required, the personal flag or pennant should be flown at the fore truck, and the national ensign is displayed at the main truck. When a single-masted flagship is dressed or full-dressed, however, the personal flag or pennant is hoisted at the starboard yardarm.

During a gun salute the ensign is displayed at the main truck. Any personal flag is lowered clear of the ensign.

Personal Flags and Pennants in Boats and Automobiles

When embarked in a boat of the naval service on official occasions, an officer in command, or a chief of staff acting for him, displays his personal flag or command pennant from the bow. If not entitled to either a personal flag or command pennant, a commission pennant is used.

An officer entitled to a personal flag or command pennant may display a miniature of his flag or pennant in the vicinity of the coxswain's station when embarked in a boat of the naval service on any trips except official occasions.

An officer entitled to display a personal flag or command pennant may, when riding in an automobile on an official occasion, display his flag or pennant forward on the vehicle.

Personal Flags of Staff Corps Officers

The personal flag of a flag officer not of the line has a white field with blue stars. Officers entitled to such flags may fly them at shore activities they command, but they are never hoisted on board ship.

Broad Command and Burgee Command Pennants

The broad command pennant is flown by an officer below flag rank when in command of a force, flotilla, squadron, carrier group, cruiser division, or an aircraft wing. If the officer is in command of any other division or a major subdivision of an aircraft wing, the burgee command pennant is displayed.

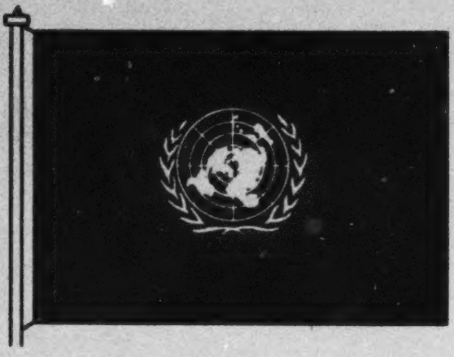
If the officer is the regularly assigned commander of the unit or is temporarily in command, the pennant is shown at the after truck of his ship whether underway or in port. When so displayed, the command pennant replaces the commission pennant.

The broad command or burgee command pennant also is exhibited in the bow of a boat in which the officer is embarked officially. (See figure 3-4.)

United Nations Flag

The flag of the United Nations (U.N.) consists of the official emblem of the United Nations centered on a blue background. (See figure 3-6.) The emblem is white and appears on both sides of the flag.

The U.N. flag flies from all buildings, offices, and other property occupied by the United Nations. The manner and circumstances of displaying it conform, insofar as appropriate, to the laws and customs applicable to flying the national flag of the country in which the display is made.



C69.4

Figure 3-6.—The United Nations flag.

The United Nations flag is shown at installations of the Armed Forces of the United States only upon occasions of visits of high dignitaries of the United Nations or on other special occasions in honor of the United Nations. At such times it is displayed with the United States flag. Both flags should be of the same approximate size and on the same level, with the flag of the United States in the position of honor on the right (observer's left).

When United Nations dignitaries are to be honored, U.S. Navy vessels display the United Nations flag in the same manner as they present a foreign ensign during visits of a foreign president or sovereign.

The President of the United States may authorize the display of the United Nations flag for other national occasions than those named.

Special Flags of U.S. Civil Officials

The personal flag of the President of the United States is shown in figure 3-7. His flag is hoisted at the main truck the moment he reaches the deck of a naval vessel, and it is kept flying until he departs. It is hauled down with the sounding of the last gun of the Presidential departure salute. The President's boat flag is smaller in size but of the same design. When he is embarked in a boat of the Navy, his boat flag is flown from a staff in the bow of the boat.

In addition to the President's personal flag, the personal flag of each of the following civil officials is also displayed at the main truck: (1) Vice President; (2) Secretary of State (when acting as a special foreign representative of the President); (3) Secretary, Deputy Secretary, and Assistant Secretary of Defense; (4) Secretary, Under Secretary, and Assistant Secretaries of the Navy.

When two or more civil officials are embarked on board a ship of the Navy or in a boat of the Navy, only the flag of the senior official is flown.

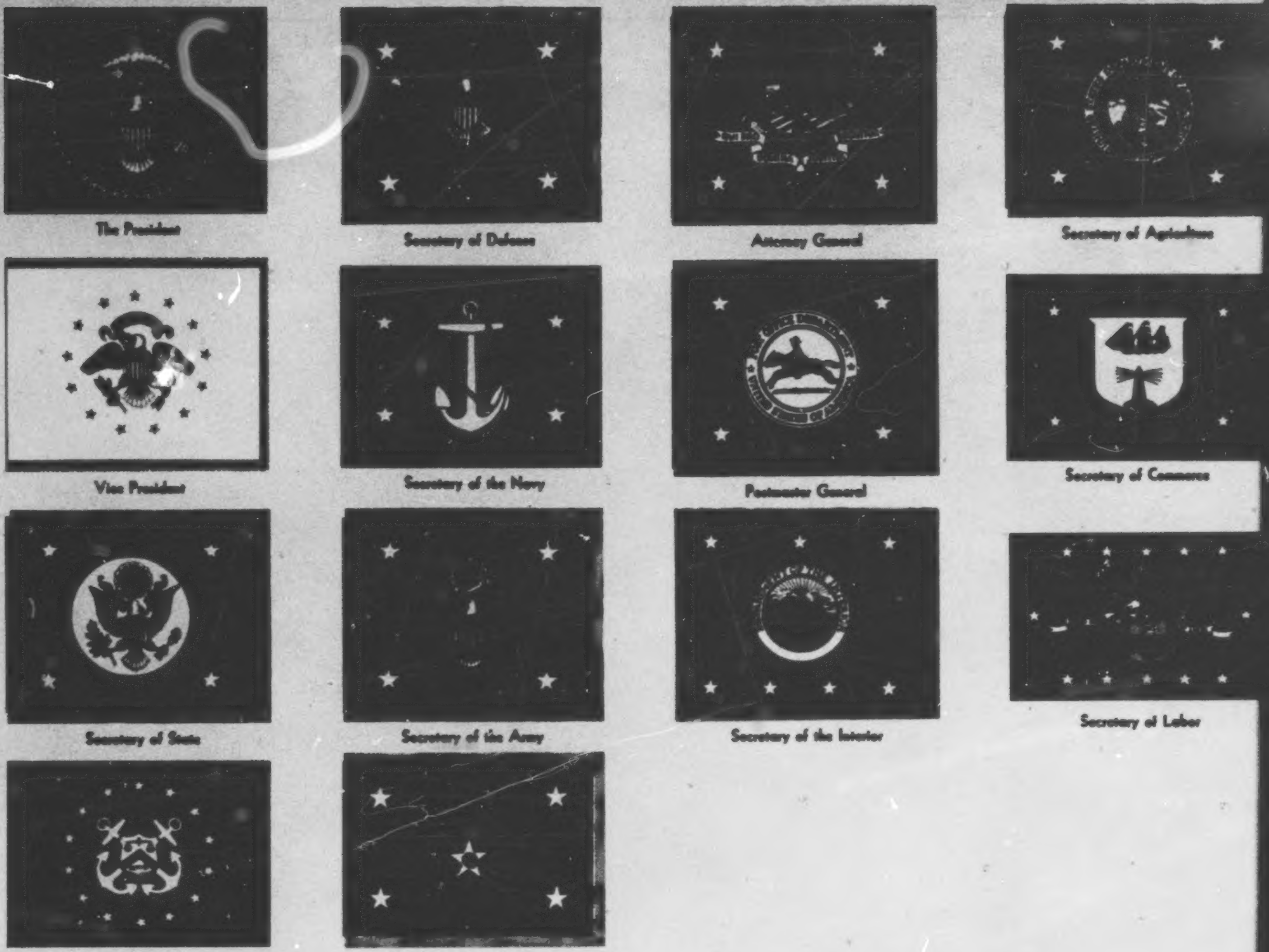
DRESSING AND FULL-DRESSING SHIP

When dressing ship, the largest national ensign the ship has is flown from the flagstaff. Except as prescribed for a ship displaying a personal flag or command pennant, a national ensign also is displayed from each masthead. The national ensigns at the mastheads should be uniform in size. If there is a substantial difference in heights of mastheads, however, a variation in the size of the national ensign is appropriate.

When the ship is full-dressed, the mastheads are dressed as described in the preceding paragraphs. A rainbow of signal flags also is displayed. They should reach from the foot of the jackstaff to the mastheads and then to the foot of the flagstaff. On peculiarly masted or mastlass ships, the display is modified as little as possible from the rainbow effect.

Ships are full-dressed on the third Monday of February and the Fourth of July. If the Fourth of July falls on a Sunday, the ceremonies are conducted the following day. Ships are dressed on remaining national holidays and at such other times as may be prescribed.

When dressing or full-dressing ship in honor of a foreign nation, the national ensign of that nation replaces the United States national ensign at the main (or at the masthead of a single-masted ship).



The President

Secretary of Defense

Attorney General

Secretary of Agriculture

Vice President

Secretary of the Navy

Postmaster General

Secretary of Commerce

Secretary of State

Secretary of the Army

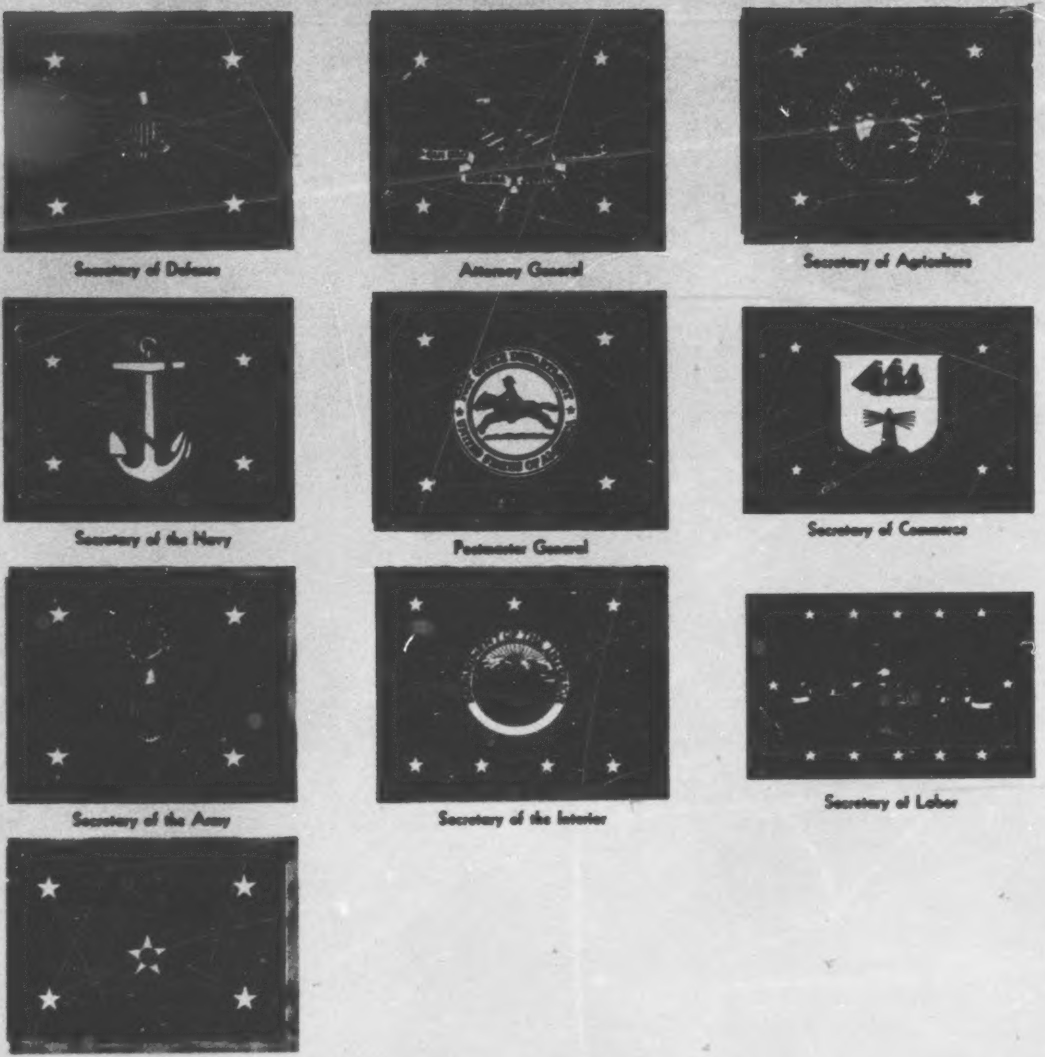
Secretary of the Interior

Secretary of Labor

Secretary of the Treasury

Secretary of the Air Force

Figure 3-7.—Personal flags of civil officials of the United States.



Secretary of Defense

Attorney General

Secretary of Agriculture

Secretary of the Navy

Postmaster General

Secretary of Commerce

Secretary of the Army

Secretary of the Interior

Secretary of Labor

Secretary of the Air Force

Figure 3-7.—Personal flags of civil officials of the United States.

C69.5

If circumstances necessitate half-masting the national ensign during dressing or full-dressing ship, only the national ensign at the flagstaff is half-masted.

When full-dressing is prescribed, the senior officer present may direct that dressing be substituted if, in his opinion, weather conditions make it advisable. Under such circumstances, he also may direct that the ensigns be hauled down from the mastheads after they are hoisted.

Ships not underway must be dressed or full-dressed from 0800 until sunset. Underway, they are not dressed or full-dressed.

Only clean flags should be used in full-dressing ship. More than one set of flags may be needed to fill all the dressing lines on large ships. Flags should be stopped to the dressing lines the day before the ship is to be full-dressed. Otherwise, something unforeseen might develop and the dressing lines would not be ready for hoisting at 0800.

FLAGS OF OTHER NATIONS

Figure 3-2 shows flags of nations not formally recognized by the United States.

Figure 3-3 shows the flags of other maritime nations of the world. As a result of wars and gain and loss of independence by different nations, this combination of flags has undergone many changes during the past 40 years. An attempt is made every few years, by our Government agencies, to bring plates of maritime nations up to date.

Any future changes in the flags and ensigns will supersede those in this training course.

CHAPTER 4

MAGNETIC COMPASS AND GYROCOMPASS

The best known and most widely used of all navigational instruments is the compass. Without it, precise information on headings and directions would be almost impossible to obtain. Compasses were used even before the days of Columbus, and they remain indispensable in today's Navy.

The Navy uses two main types of compasses: gyroscopic and magnetic. The gyrocompass operates on the principle that a rapidly spinning object is balanced at its center of gravity, much as a spinning top stands on its point. The gyrocompass is designed to point toward true North though it may have a slight mechanical error (1° or 2°), which may be determined and for which allowance is made. The magnetic compass, on the other hand, is controlled primarily by the magnetic properties of the Earth and tends to point toward the magnetic north pole.

MAGNETISM

To fully understand the operation of the magnetic compass, it is necessary to know something about magnets themselves. A magnet is a body that has the property of attracting iron and producing a magnetic field around itself. Such materials as lodestone and magnetic oxide of iron, in their natural state, possess this property. The Earth itself has similar properties and may be considered a gigantic magnet.

Every magnet has a north pole and a south pole. If a single magnet is cut in half, each half becomes a magnet with a north pole and a south pole. If two magnets are brought close together, their unlike poles will attract and their like poles repel. That is, a north pole attracts a south pole but repels another north pole. This law of magnetism has meaning for you inasmuch as you later will see how the magnets in a ship's magnetic compass observe this law in relation to the Earth's magnetic fields or to the ship's own magnetic properties.

EARTH'S MAGNETISM

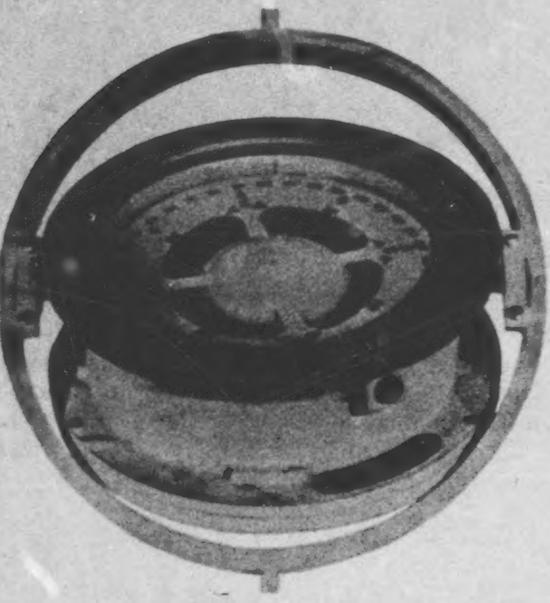
The Earth, like all other magnets, has a magnetic north pole, located approximately at 74.0° north latitude, 101.0° west longitude, and a magnetic south pole, located approximately at 68.0° south latitude, 144.0° east longitude. They are distinguished from the true North and South Poles which are at 90° north latitude and 90° south latitude, respectively.

The magnetic lines of force that connect the magnetic poles are called magnetic meridians. These meridians are not great circles. Because of the irregular distribution of magnetic material in the Earth, the meridians are irregular, and the planes of the magnetic meridians do not pass through the center of the Earth. Approximately midway between the magnetic poles is a line called the magnetic equator.

The magnetic equator is an irregular arc, varying in latitude from 15° south in South America to 20° north in Africa.

MAGNETIC COMPASS

Although you were introduced to the magnetic compass in the Seaman course, your job as Quartermaster requires a much more thorough knowledge of the intricacies of the magnetic compass. Accordingly, this topic presents detailed information on the magnetic compass, its nomenclature, and its limitations.



45.595(69)
Figure 4-1.—U.S. Navy 7½-inch standard compass.

COMPASS NOMENCLATURE

The simplest magnetic compasses, as you know, contain magnets whose south ends tend to seek the Earth's north magnetic pole, thus giving the compass its directive force.

Magnetic compasses used in the Navy (figure 4-1) are highly sophisticated instruments. In addition to the magnets, magnetic compasses are made up of a number of parts. Components of a standard 7-½-inch diameter Navy compass are given in the accompanying list.

1. Magnets: Four (two in older compasses) cylindrical bundles of steel wire, with magnetic properties, which are attached to the compass card to supply directive force.
2. Compass card: An aluminum disk graduated in degrees from 0 to 359. It also shows cardinal and intercardinal points.
3. Compass bowl: A bowl-shaped container, made of nonmagnetic material (brass), with a reference mark on its rim. The bowl contains the magnetic element and the fluid. Part of the bottom may be transparent (glass) to permit light to shine upward against the compass card.

4. Fluid: A liquid surrounding the magnetic element. By reduction of weight, in accordance with the Archimedes principle of buoyancy, friction is reduced. Closer alignment of the compass needle with the magnetic meridian is thus possible. The liquid in older compasses may be a mixture of ethyl alcohol and water in approximately equal parts. Alcohol serves to lower the freezing point of the mixture. Newer compasses contain varsol, an oil that neither freezes nor becomes more viscous at low temperatures.

5. Float: An aluminum air-filled chamber in the center of the compass card to further reduce weight and friction at the pivot point.

6. Expansion bellows: A bellows arrangement in the bottom of the compass bowl, which operates to keep the compass bowl completely filled with liquid. A filling screw facilitates adding liquid when necessary.

7. Lubber's line: A mark on the inside of the compass bowl, which is aligned with the ship's fore-and-aft axis. The lubber's line is a reference for reading direction from the compass card. The compass card reading on the lubber's line represents the ship's heading.

8. Gimbals: The compass bowl has two pivots that fit or rest in a metal ring, which also has two pivots resting in the binnacle. This arrangement (gimbals) permits the compass to remain almost horizontal despite the motion of the ship. An important concept is that, regardless of the movement of the ship, the compass card remains fixed. The ship, the compass bowl, and the lubber's line move together around the compass card. To the observer, as he witnesses this relative motion, it appears that the compass card moves.

9. Binnacle: A nonmagnetic housing in which the magnetic compass is mounted. It usually provides a means for inserting corrector magnets for compass adjustment.

COMPASS LIMITATIONS

The following characteristics of the magnetic compass limit its direction-finding ability.

1. It is sensitive to any magnetic disturbance.

2. It is useless at the magnetic poles, and is sluggish and unreliable in areas near the poles.

3. Deviation (explained later) changes as a ship's magnetic properties change. Moreover, the magnetic properties change with changes in the ship's structure or magnetic cargo.

4. Deviation changes with heading. The ship as well as the Earth may be considered as a magnet. The effect of the ship's magnetism upon the compass changes with the heading.

5. It does not point to true North.

6. It requires frequent adjustments.

PRECAUTIONS IN VICINITY OF MAGNETIC COMPASS

A magnetic compass cannot be expected to give reliable service unless it is properly installed and protected from disturbing magnetic influences. Certain precautions must be observed in the vicinity of the magnetic compass. Some of these precautions follow:

If avoidable, a compass should not be placed near iron or steel equipment that will be moved frequently. Thus, a location near a gun, boat davit, or boat crane is not desirable. The immediate vicinity should be kept free of sources of magnetism, particularly those of a changing nature. When avoidable, no source of magnetism should be permitted within a radius of several feet of the magnetic compass. Some sources that might be overlooked include electric wires carrying direct current; magnetic instruments, searchlights, windshield wipers, electronic equipment, or motors; steel control rods, gears, or supports associated with the steering apparatus; fire extinguishers, gas detectors, etc.; and metal hangers, flashlights, keys, or pocketknives.

STANDARD AND STEERING COMPASSES

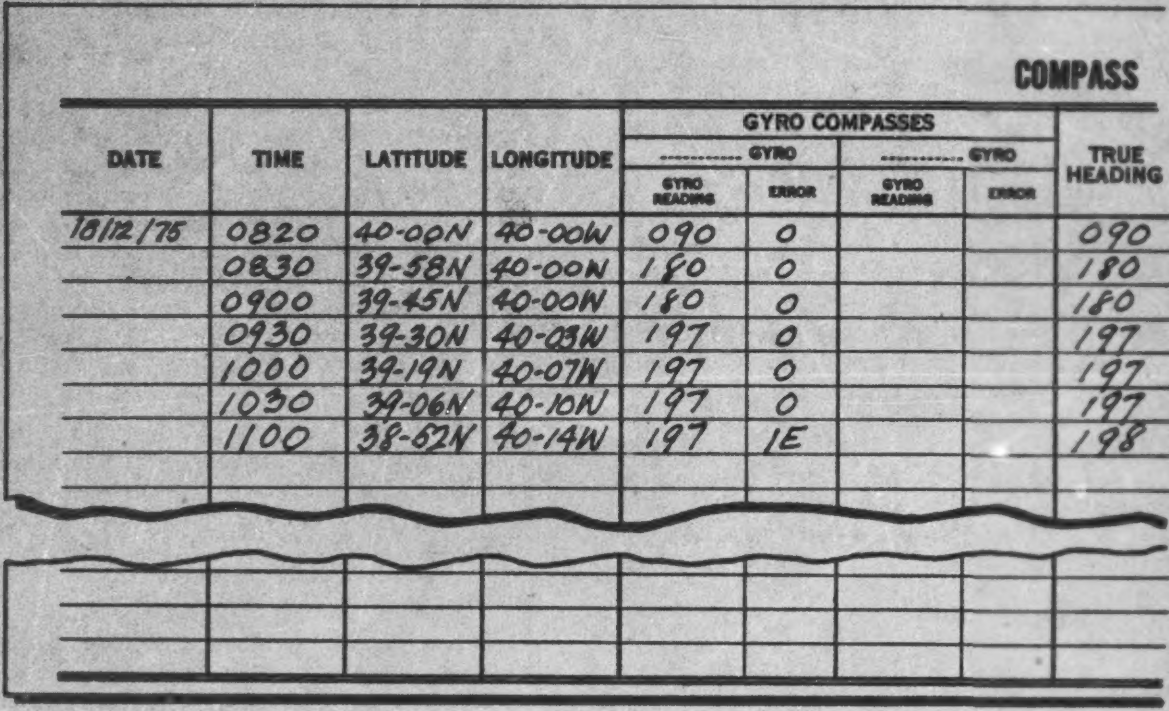
The magnetic steering compass is located in the pilothouse, where it is affected considerably by deviation. Usually the standard compass is topside, where the magnetic forces producing deviation are not so strong. Courses and bearings by these compasses must be carefully differentiated by the abbreviations psc (per standard compass), pstgc (per steering compass), and pgc (per gyrocompass). The standard compass provides a means for checking the steering compass and the gyrocompass.

The steering compass on many ships has been replaced by a repeater, which transmits indications from a magnesyn compass. (The word magnesyn is formed from the term "magnetic synchronized.") It is located on a mast or at some other point where deviation is at a minimum.

Some ships may have a third magnetic compass located at the after steering station when that station is topside. This compass is known as the emergency steering compass.

MAGNETIC COMPASS RECORD BOOK

According to provision of Navy Regulations, the magnetic compass record must be a complete record of all direct reading and remote indicating magnetic compasses on board. It also must be a record of errors of the gyrocompasses on board. While a vessel is underway, comparison between the magnetic and gyrocompass headings must be made and entered in the record whenever a new course is set, unless impracticable. Under circumstances such as emergencies or frequent course changes within a harbor, these comparisons may be omitted. Compass comparisons must also be made at least every 30 minutes for one magnetic compass and the master gyrocompass (or the ship's heading indicator used for steering) and every 4 hours for all other installed compasses. The compass record book must be signed by the navigator and submitted to the commanding officer for his approval on the last day of every quarter. Figure 4-2 shows a sample page from the magnetic compass record book.



COMPASS

DATE	TIME	LATITUDE	LONGITUDE	GYRO COMPASSES				TRUE HEADING
				---------- GYRO		---------- GYRO		
				GYRO READING	ERROR	GYRO READING	ERROR	
18/12/75	0820	40-00N	40-00W	090	0			090
	0830	39-58N	40-00W	180	0			180
	0900	39-45N	40-00W	180	0			180
	0930	39-30N	40-03W	197	0			197
	1000	39-19N	40-07W	197	0			197
	1030	39-06N	40-10W	197	0			197
	1100	38-52N	40-14W	197	1E			198

69.137

Figure 4-2.—Magnetic compass record book—sample page.

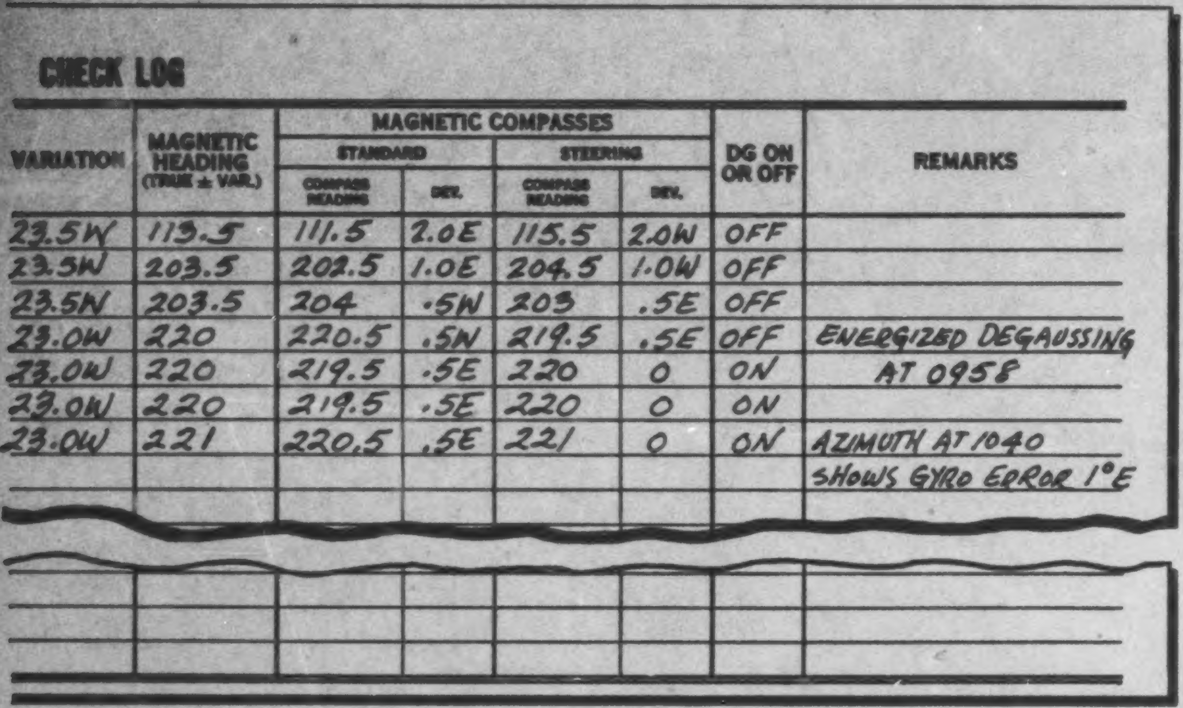
MAGNETIC COMPASS ERROR

Compass error, defined as the inclination of the axis of the compass card to the true meridian, may be computed easily. It is simply the algebraic sum of variation and deviation. Compass error (figure 4-3) must be applied to a compass direction to obtain true direction. It must be applied to true direction, with signs reversed, to arrive at compass direction.

VARIATION

Because the magnetic north pole and the true North Pole are not located at the same point, the magnetic compass does not seek true North. The magnetic compass aligns itself with the direction of the horizontal component of the Earth's magnetic field at the compass location, and therefore does not always point toward the north magnetic pole. The amount the needle is offset is called variation because it varies at different points on the Earth' surface. Even in the same locality it usually doesn't remain constant, but increases or decreases annually at a certain known rate.

The variation for any given locality is shown on the compass rose of the chart for that particular locality, together with the amount of annual increase or decrease. In the following discussion, symbols are used for degrees (°) and minutes ('). The compass rose in figure 4-4 indicates that in 1969 there was a 14°45' westerly variation in that area, increasing 1' annually. To find the amount of variation in this specific locality in 1976, determine how many years have elapsed since 1969 (which is 7), multiply that number by the amount of annual increase (which gives you 7 times 1', or 7'), and add that sum to the variation in 1969. You add it in this example because it is an annual



CHECK LOG

VARIATION	MAGNETIC HEADING (TRUE ± VAR.)	MAGNETIC COMPASSES				DG ON OR OFF	REMARKS
		STANDARD		STEERING			
		COMPASS READING	DEV.	COMPASS READING	DEV.		
23.5W	113.5	111.5	2.0E	115.5	2.0W	OFF	
23.5W	203.5	202.5	1.0E	204.5	1.0W	OFF	
23.5W	203.5	204	.5W	203	.5E	OFF	
23.0W	220	220.5	.5W	219.5	.5E	OFF	ENERGIZED DEGAUSSING
23.0W	220	219.5	.5E	220	0	ON	AT 0958
23.0W	220	219.5	.5E	220	0	ON	
23.0W	221	220.5	.5E	221	0	ON	AZIMUTH AT 1040
							SHOWS GYRO ERROR 1°E

69.137

Figure 4-2.—Magnetic compass record book—sample page.

increase. If it were decreasing, you would subtract it.

The variation in 1969 was 14°45'W. Add 7' to that amount, and you have a 1976 variation of 14°52'W. Variation normally is rounded off to the nearest 0.5°.

Variation remains the same for any heading of the ship at a given locality. No matter which direction the ship is heading, the magnetic compass, if affected by variation only, points steadily in the general direction of the magnetic north pole.

DEVIATION

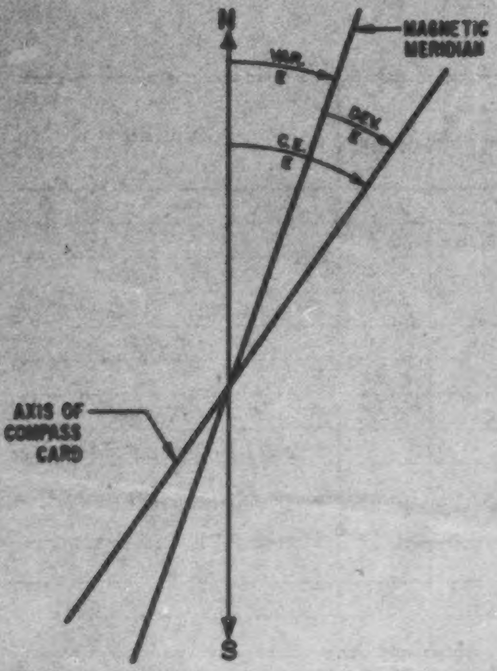
The amount a magnetic compass needle is deflected by magnetic material in the ship around it is called deviation.

The most convenient method of determining deviation, and the one most commonly used, is to check your compass on each 15° heading against a properly functioning gyrocompass. Because your ship must be on a magnetic heading when determining deviation, gyro error and local variation must be applied to each true heading. When using this procedure, it is only necessary to station personnel at each magnetic compass and have them record the amount of deviation for each compass upon signal from an observer at the gyrocompass or repeater.

Some other methods of finding deviation follow.

1. By comparison with a magnetic compass of known deviation: This method is similar to comparison with a gyrocompass except that it is unnecessary to know the local variation. This method is used frequently by ships not equipped with gyrocompasses.

2. By reciprocal bearings: One observer is stationed ashore with a spare compass, which is placed where it is free from local magnetic influences. An observer aboard the ship stands

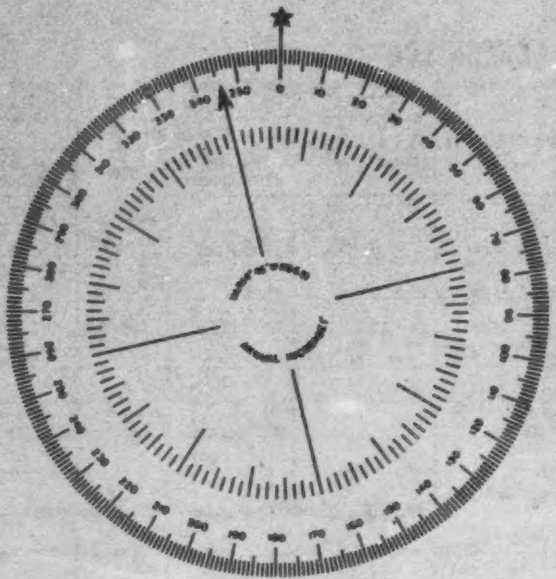


69.138

Figure 4-3.—Components of compass error.

by the compass to be checked. When the ship is steady on the desired heading, a prearranged signal is made, and each observer notes the bearing of the other. The reverse bearing of the compass ashore, which has no deviation, is the magnetic bearing of the ship. The difference between this bearing and the bearing indicated by the compass on board is the amount of deviation on that particular heading. This method is not very convenient and probably will never be used on your ship until all other methods of determining are exhausted.

3. By ranges: This method uses a range whose magnetic bearing is known. The ship steams on the various headings, and notes the bearing of the range on her compasses for each heading as she crosses the range. The deviation for each compass is the difference between the known magnetic bearing of the range and the bearing indicated on the compass. Further disucssion of ranges is in chapter 5 of this manual.



45.23(69)

Figure 4-4.—Compass rose.

4. By azimuths of the Sun or other celestial body: In this method the magnetic azimuth of the body is determined by applying local variation to the body's true azimuth. Computing an azimuth of the Sun by using H.O. 229 is described in chapter 12 of this manual. The difference between the body's magnetic azimuth and its compass azimuth is the deviation for that particular heading.

5. By distant objects: In this method the ship must be a considerable distance from a conspicuous object, with a clearly defined point on which to take bearings. If the ship is being swung at anchor, the object should be at least 6 miles away. If she is steaming on different headings, the fact that she does not remain on the same spot requires that the object be at least 10 miles away. The ship is steadied on successive headings, and the compass bearing of the object is taken on each heading. Magnetic bearings may be found from a chart. As before, deviation on each heading is the difference between compass and magnetic bearing of the object. This method has been almost completely discarded in favor of

the other methods. It is described here so that it can be used in extreme circumstances.

CORRECTING COMPASS ERROR

Variation and deviation combined constitute magnetic compass error. The course on which you want the ship to head is the true course, worked out from the chart on which true courses and bearings are given. Knowing the true course, it is necessary for you to find the compass course you must steer to make good the true course. Compass course is found by applying the compass error, in terms of variation and deviation, to the true course.

Your problem could be the other way around. Suppose you have a bearing taken by magnetic compass. Plotting true bearings on the chart is preferable to plotting magnetic bearings. Therefore, you must apply variation and deviation to the compass bearing to obtain the true bearing.

Changing from true course to compass course, or vice versa, may be accomplished more easily by means of this handy key, in the form of the question: CAN DEAD MEN VOTE TWICE? Of course, it's a sure bet that dead men can't vote once, let alone twice; hence this question has no actual meaning. As already pointed out, it is merely handy in solving our problem of correcting compass error.

First, write each word of the question in column form, then opposite each word set down what it represents, as follows:

Can	Compass
Dead	Deviation
Men	Magnetic
Vote	Variation
Twice	True

Your problem will always be either (knowing the true course) to work up the line to the compass course, or (knowing the compass course) to work down the line to the true course. Going up the line, or changing from true to compass, is called uncorrecting. Coming down the line, or changing from compass to true, is called correcting. All you actually have to remember is this rule: When correcting, ADD easterly and SUBTRACT westerly error. When uncorrecting, SUBTRACT easterly and ADD westerly error. It is as simple as that. All compass errors, whether due to variation or deviation, are either easterly or westerly. There are no northerly or southerly errors.

Now, let's work a problem. Suppose the true course you want to head is 000° and you want to know the course to steer by magnetic compass. In other words, you are uncorrecting. This time, write the initial letters of each word of the old question in a line.

←—W + E—→
C D M V T

You already know what T is, so write it down.

←—W + E—→
C D M V T
000°

Let's say the chart shows a variation of 11°E. Now you have:

←—W + E—→
C D M V T
11°E 000°

When uncorrecting, remember that you substract easterly and add westerly errors. This 11° is an easterly variation, so you subtract it from 360° and get a magnetic course of 349°. Write that down.

←—W + E—→
C D M V T
349° 11°E 000°

Occasionally, you need to know a magnetic heading or bearing. If that were all you were looking for in this example, you could stop right here. This time, however, you want to go on and find the compass course. Let's say the deviation table shows a deviation of 14°W for a 349° heading. Write that down.

←—W + E—→

C D M V T
14°W 349° 11°E 000°

When uncorrecting, you add westerly error, so add 14° to 349° and get 003°. Now you have:

←—W + E—→

C D M V T
003° 14°W 349° 11°E 000°

In order to head 000° true, therefore, you must steer 003° by this particular magnetic compass.

Note in our sample problem that the easterly variation and westerly deviation almost canceled each other, leaving an error of only 3°W. If you don't want to go through the correction process in detail, you can find the algebraic sum of the errors beforehand. This advance preparation is accomplished by subtracting the lesser from the greater, if they are unlike, or adding them if they are like. Then you can apply the result directly to either T or C, depending on whether you are correcting or uncorrecting.

We were uncorrecting this time—changing from true to compass. We could have used the same method to change from compass to true, but we must remember that, when correcting, we add easterly and subtract westerly errors.

ADJUSTING VERSUS COMPENSATING

As you know by now, magnetic material around the compass is a cause of deviation. Another cause of compass deviation is electrical circuits. In particular, the ship's degaussing currents have a strong effect on the magnetic compass. (Degaussing, discussed later, is an electrical installation designed to protect ships against magnetic mines and torpedoes.) The deviation resulting from these currents is neutralized by a procedure called compensation. You should distinguish between adjusting the compass, which means correcting for deviations caused by magnetic material, and compensating the compass, which means correcting for deviations produced by degaussing currents.

DEGAUSSING

In discussing the magnetic compass, we mentioned that it is affected by degaussing. A Quartermaster will be concerned with how degaussing works and why it is necessary. The subject is explained in the ensuing topics.

SHIP'S MAGNETIC FIELD

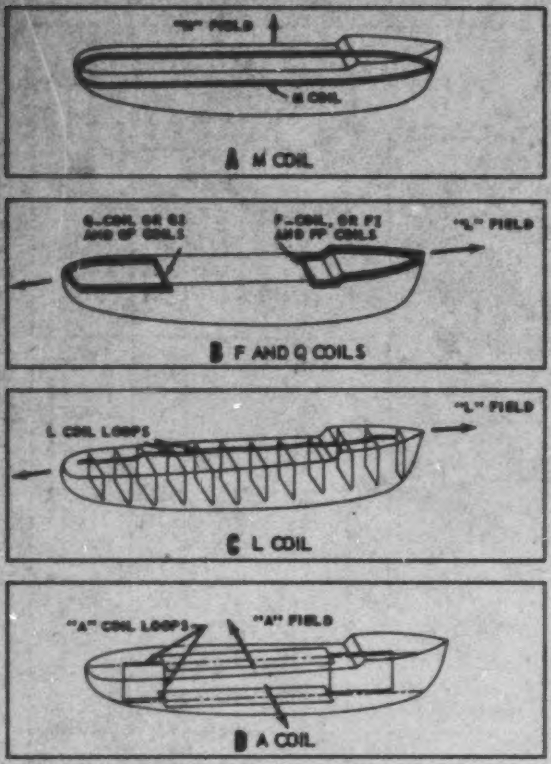
A ship is a magnet because of magnetic material (steel) in its hull, machinery, and cargo. Like any other magnet, it is surrounded by a magnetic field that is large near the ship and small at a considerable distance from it. When a ship is close to a magnetic mine or magnetic torpedo, the magnetic field of the ship actuates the firing mechanism and causes the mine or torpedo to explode.

The purpose of degaussing is to counteract the ship's magnetic field and establish a condition such that the magnetic field near the ship is, as nearly as possible, just the same as if the ship were not there. If this condition could be realized perfectly, the magnetic mine could not detect the presence of the ship and would not explode. Even though this condition cannot be realized perfectly, an approximation to such a condition decreases the danger from magnetic mines.

Two methods are used to decrease a ship's magnetic field. They are the magnetic treatment (called deperming) and the shipboard degaussing installation.

Magnetic Treatment

Magnetic treatment is given by deperming stations, using coils installed temporarily on or around a ship, to provide antimine protection. This treatment reduces the overall magnetic field of the ship so there is less chance of activating a magnetic mine or magnetic torpedo. Magnetic treatment furnishes some protection but is not so effective as the protection afforded by shipboard degaussing installations. Magnetic treatment is seldom used alone.



27.107

Figure 4-5.—Types of degaussing coils.

Shipboard Degaussing Installation

A shipboard degaussing installation consists of permanently installed equipment. The major items are degaussing coils, a power source for the coils, a control unit to control the coil current (which, in turn, controls the strength of the magnetic field caused by the coils), and compass compensating equipment to prevent disturbances of the magnetic compasses by the magnetic field of the degaussing coils.

Since it may become necessary for the Quartermaster to apply corrections to degaussing coils due to changes in course, the following discussion is designed to assist you in understanding the coils and the operations required to make corrections to their applied current.

Figure 4-5 illustrates the types of coils that are found on a typical degaussing installation.

The M or main coil (part A, figure 4-5) encircles the ship in a horizontal plane, which is usually at about the water level. The function of the M coil is to produce a magnetic field which counteracts the magnetic field produced by the vertical permanent and the vertical induced magnetization of the ship.

The F or forecastle coil encircles the forward one-fourth to one-third of the ship and is usually just below the forecastle or other uppermost deck; whereas the Q or quarterdeck coil encircles the after one-fourth to one-third of the ship and is usually just below the quarterdeck or other uppermost deck (part B, figure 4-5). The function of the F and Q coils is to counteract the magnetic field produced by the ship's longitudinal permanent and induced magnetization.

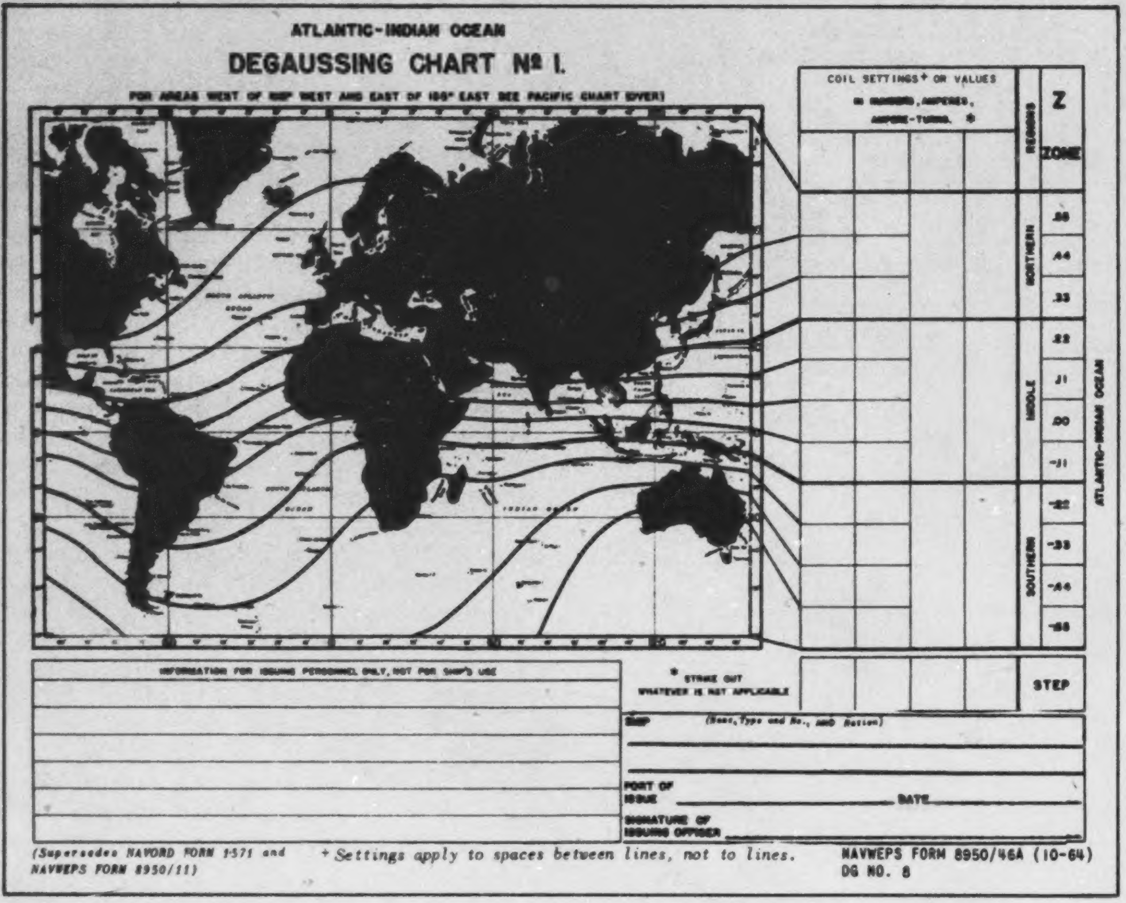
In numerous installations the conductors of the F and Q coils are connected to form two separate circuits, designated FI-QI coil and the FP-QP coil (part B, figure 4-5). The FI-QI coil consists of an FI coil connected in series with a QI coil so that the same current flows in both. The FP-QP coil is similar.

The FI-QI coil is used to counteract the magnetic field produced by the ship's longitudinal induced magnetization. The FP-QP coil is used to counteract the magnetic field produced by the ship's longitudinal permanent magnetization.

The L or longitudinal coil (part C, figure 4-5) consists of loops in vertical planes parallel to the frames of the ship. The function of the L coil is to counteract the magnetic field produced by the ship's longitudinal permanent and induced magnetization. It does this better than F and Q coils, or FI-QI and FP-QP coils. For this reason, the L coil is often used in minesweeper vessels.

The A or athwartship coil (part D, figure 4-5) consists of loops in vertical fore-and-aft planes. The function of the A coil is to produce a magnetic field that will counteract the magnetic field caused by the athwartship permanent and induced magnetization.

The magnetic field produced by a degaussing coil (coil strength) is proportional to the ampere turns NI, the product of the number of turns in the coil by the coil current in amperes. A


ATLANTIC-INDIAN OCEAN
DEGAUSSING CHART Nº I.
FOR AREAS WEST OF 160° WEST AND EAST OF 160° EAST SEE PACIFIC CHART (OVER)
COIL SETTINGS + OR VALUES
IN HUNDRED, AMPERES, AMPERE-TURNS. *
REGIONS
Z ZONE
NORTHERN
.55
.44
.33
.22
MIDDLE
.11
.00
-.11
-.22
SOUTHERN
-.33
-.44
-.55
ATLANTIC-INDIAN OCEAN
STEP
INFORMATION FOR ISSUING PERSONNEL ONLY, NOT FOR SHIP'S USE
* STRIKE OUT WHATEVER IS NOT APPLICABLE
SHIP (Name, Type and No., AND Nation)
PORT OF ISSUE
DATE
SIGNATURE OF ISSUING OFFICER
(Supersedes NAVORD FORM 1571 and NAVWEPS FORM 8950/11)
+ Settings apply to spaces between lines, not to lines.
NAVWEPS FORM 8950/46A (10-64)
DG NO. 8

69.14

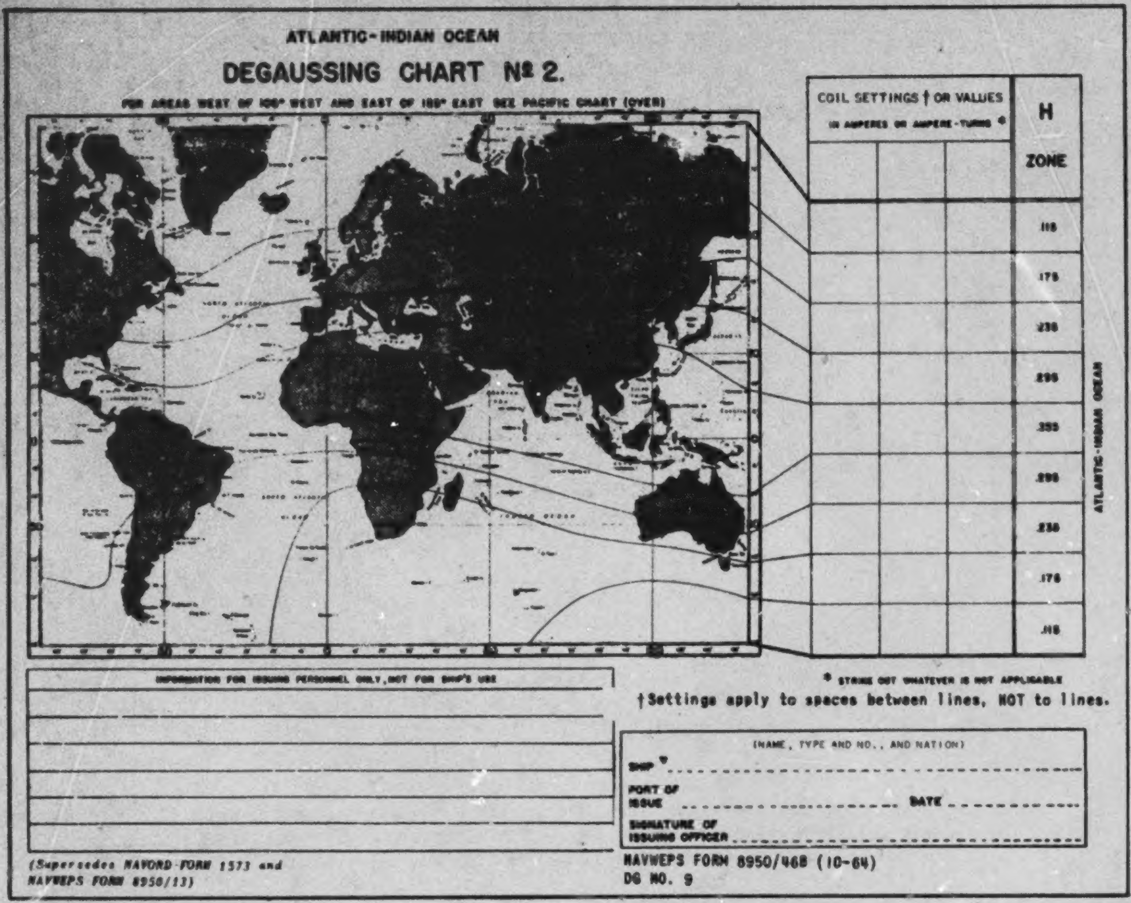
Figure 4-6.—Degaussing chart No. 1.

specified number of ampere turns can be obtained by using one turn and a current numerically equal to the required ampere turns, or by using more turns and a correspondingly smaller current.

DEGAUSSING SETTING

Energizing the degaussing equipment consists of setting the coil currents and maintaining them at the values specified in the charts comprising the degaussing folder (NAVORD Form 1547). Quartermasters must be able to read and interpret the degaussing charts contained in this folder. On some ships you may have to make the degaussing settings yourself but on other ships Electricians Mates make the settings.

Degaussing Chart No. 1 is shown in figure 4-6. This chart divides the vertical intensity (Z-component) of the Earth's magnetic field into Z-zones. When your ship passes from one Z-zone to another, the coil setting is changed to the value given for that coil in the new zone. Make a correction for each coil requiring a change. These changes are made on a rheostat-ammeter setup located on the bridge. As an alternative, pass the information to the


ATLANTIC-INDIAN OCEAN
DEGAUSSING CHART Nº 2.
FOR AREAS WEST OF 100° WEST AND EAST OF 100° EAST SEE PACIFIC CHART (OVER)
COIL SETTINGS † OR VALUES
IN AMPERES OR AMPERE-TURNS *
H
ZONE
.115
.175
.235
.295
.355
.295
.235
.175
.115
ATLANTIC-INDIAN OCEAN
INFORMATION FOR ISSUING PERSONNEL ONLY, NOT FOR SHIP'S USE
* STRIKE OUT WHATEVER IS NOT APPLICABLE
† Settings apply to spaces between lines, NOT to lines.
(NAME, TYPE AND NO., AND NATION)
SHIP *
PORT OF ISSUE
DATE
SIGNATURE OF ISSUING OFFICER
(Supersedes NAVORD FORM 1573 and NAVWEPS FORM 8950/13)
NAVWEPS FORM 8950/46B (10-64)
DG NO. 9

69.15

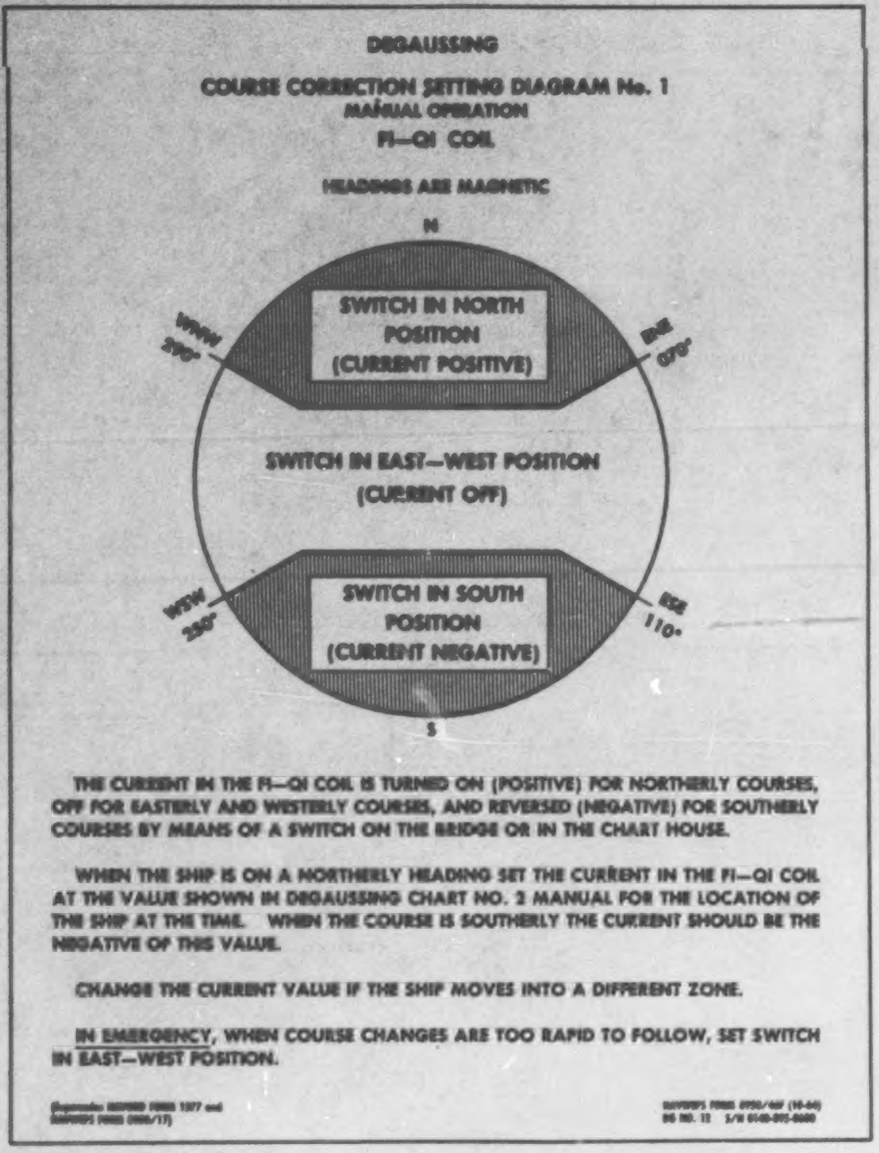
Figure 4-7.—Degaussing chart No. 2.

Electrician's Mates so they can make the correction.

Let's say you are traveling from the Caribbean Sea to the Gulf of Mexico. This travel means that you will pass from a zone where the M-coil setting is altered from 52 to 68 amps. At the same time the L coil setting is changed from 9 to 11 amps.

Degaussing Chart No. 2 (figure 4-7) divides the horizontal intensity (H-component) of the Earth's magnetic field into H-zones. When your ship passes from one H-zone to another, you must make correction settings comparable to those described for Z-zones. You may have to make corrections for all the coils when you pass from zone to zone, or you may need to change only one or two.

Figure 4-8 diagrams the course correction setting for the current in coil FI-QI. This diagram means that, if you are on a southerly course, the polarity switch must be set so that the current is negative. If your course is northerly, the polarity switch is set at the opposite (positive) position. If you are traveling east or west, the current is shut off. The course correction setting for coils FI-QI and A are shown in figure 4-9. Quartermasters must ensure



DEGAUSSING

COURSE CORRECTION SETTING DIAGRAM No. 1
MANUAL OPERATION
FI—QI COIL

HEADINGS ARE MAGNETIC

SWITCH IN NORTH POSITION (CURRENT POSITIVE)

SWITCH IN EAST—WEST POSITION (CURRENT OFF)

SWITCH IN SOUTH POSITION (CURRENT NEGATIVE)

THE CURRENT IN THE FI—QI COIL IS TURNED ON (POSITIVE) FOR NORTHERLY COURSES, OFF FOR EASTERLY AND WESTERLY COURSES, AND REVERSED (NEGATIVE) FOR SOUTHERLY COURSES BY MEANS OF A SWITCH ON THE BRIDGE OR IN THE CHART HOUSE.

WHEN THE SHIP IS ON A NORTHERLY HEADING SET THE CURRENT IN THE FI—QI COIL AT THE VALUE SHOWN IN DEGAUSSING CHART NO. 2 MANUAL FOR THE LOCATION OF THE SHIP AT THE TIME. WHEN THE COURSE IS SOUTHERLY THE CURRENT SHOULD BE THE NEGATIVE OF THIS VALUE.

CHANGE THE CURRENT VALUE IF THE SHIP MOVES INTO A DIFFERENT ZONE.

IN EMERGENCY, WHEN COURSE CHANGES ARE TOO RAPID TO FOLLOW, SET SWITCH IN EAST—WEST POSITION.

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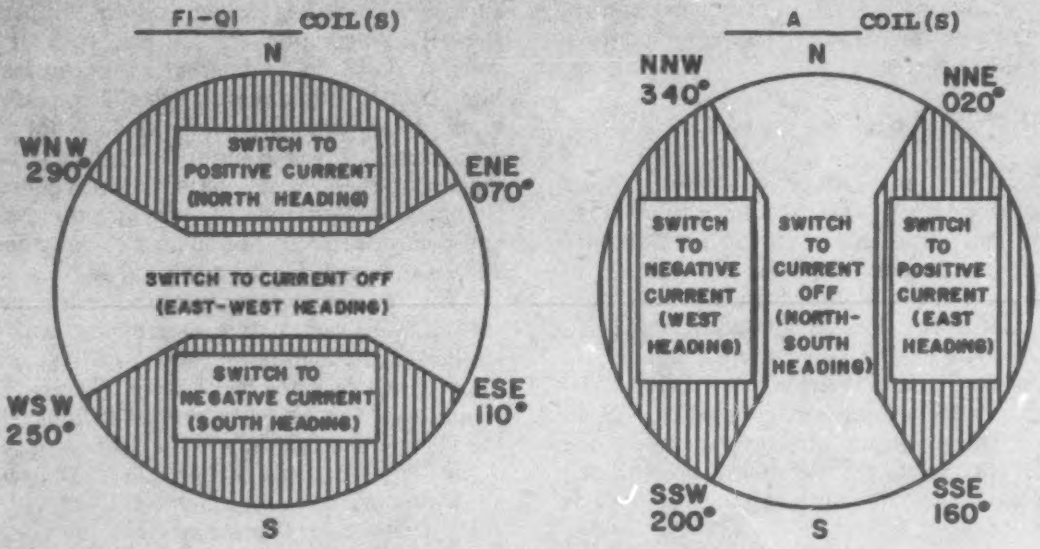
Figure 4-8.—Degaussing course correction setting diagram No. 1.

that the course correction settings are set properly.

In most degaussing installations, the degaussing coil currents are set to the required values and are checked by an Electrician's Mate at least once every hour. They are readjusted to the correct value when necessary. This continual check is necessary because changes in degaussing coil resistance, created by variations in both the cable temperatures and in the voltage of the

DEGAUSSING
COURSE CORRECTION DIAGRAM NO. 2-A
MANUAL OPERATION
HEADINGS ARE MAGNETIC


FI-QI COIL(S)
N
WNW 290°
ENE 070°
SWITCH TO POSITIVE CURRENT (NORTH HEADING)
SWITCH TO CURRENT OFF (EAST-WEST HEADING)
SWITCH TO NEGATIVE CURRENT (SOUTH HEADING)
WSW 250°
ESE 110°
S
A COIL(S)
N
NNW 340°
NNE 020°
SWITCH TO NEGATIVE CURRENT (WEST HEADING)
SWITCH TO CURRENT OFF (NORTH-SOUTH HEADING)
SWITCH TO POSITIVE CURRENT (EAST HEADING)
SSW 200°
SSE 160°
S

1. DEGAUSSING COIL HEADING SWITCH MUST BE KEPT IN POSITION CORRESPONDING TO MAGNETIC HEADING OF SHIP IN ORDER TO OBTAIN PROPER CURRENT POLARITIES AND MAGNITUDES.
2. THE SETTINGS OR CURRENT VALUES ARE OBTAINED FROM DEGAUSSING CHART NO. 2-S MANUAL. SWITCH POSITIONS REQUIRED DURING SET-UP OF CURRENTS ARE:
   FI-QI COIL(S), NORTH POSITION
   A COIL(S), EAST POSITION
3. IN EMERGENCY, WHEN COURSE CHANGES ARE TOO RAPID TO FOLLOW, TURN COILS OFF TO WHICH THIS SWITCH APPLIES.

(Supersedes NAVWEPS 8950/40C)

NAVSHIPS 8950/146 (REV. 3-67)
DG NO. 13
8-33561

69.17

Figure 4-9.—Degaussing course correction setting diagram No. 2.

power supply for the degaussing coils, alter the degaussing coil currents. The coil currents must have the correct polarity. If the polarity setting of any coil is incorrect, the ship is in much greater danger from magnetic mines than if the ship has no degaussing system installed because then the total magnetic field of the ship is stronger than before. On the bridge, the Quartermaster checks the polarity of the coils hourly by observing the neon indicator light on the control panel.

Most new vessels are equipped with automatic degaussing control equipment to change coil currents automatically, when required, because of roll and pitch, and because of changes in ship's heading and in ship's position with respect to the Earth's magnetic field. Under certain conditions, a manual coil current adjustment still is necessary, however, as explained in the degaussing folder. Indicator lights, standard on all automatic control equipment, show when the equipment is functioning incorrectly.

MAGNETIC RANGES

A magnetic range, which is commonly called a degaussing range, is a station equipped to measure and record the magnetic field of ships which pass over measuring equipment located at or near the bottom of the channel in which the ship travels. The measurements recorded are used to compute the coil currents required to give minimum magnetic fields below a ship.

The procedure for making a run on a magnetic range starts with a request to the station. Usually the Quartermaster is charged with seeing that the authorized procedure is carried out.

After receiving an affirmative reply from the station, an immediate check is made of the degaussing chart to get the correct setting for each coil installed, both for the geographic location and for the heading of the ship at the time of crossing the range. These settings are made and checked before the run is started. The commanding officer adjusts the ship's speed in accordance with instructions from the station. It is customary to run the range on one heading, followed by a run on the opposite heading.

Results of the runs are entered in the ship's degaussing folder by personnel of the station. Through periodic checks of the equipment in this manner, any shortcomings can be detected easily and corrected immediately so that protection will be available when it is needed.

COMPASS COMPENSATING EQUIPMENT

The Quartermaster needs to know how to protect the ship's magnetic compasses from the magnetic influence of the degaussing system. An unattended energized degaussing system could develop a magnetic field of sufficient magnitude to make the compasses useless for navigation.

The purpose of compass compensating coils is to set up a magnetic field that is equal to and opposite the degauging coil field in the immediate vicinity of the compasses.

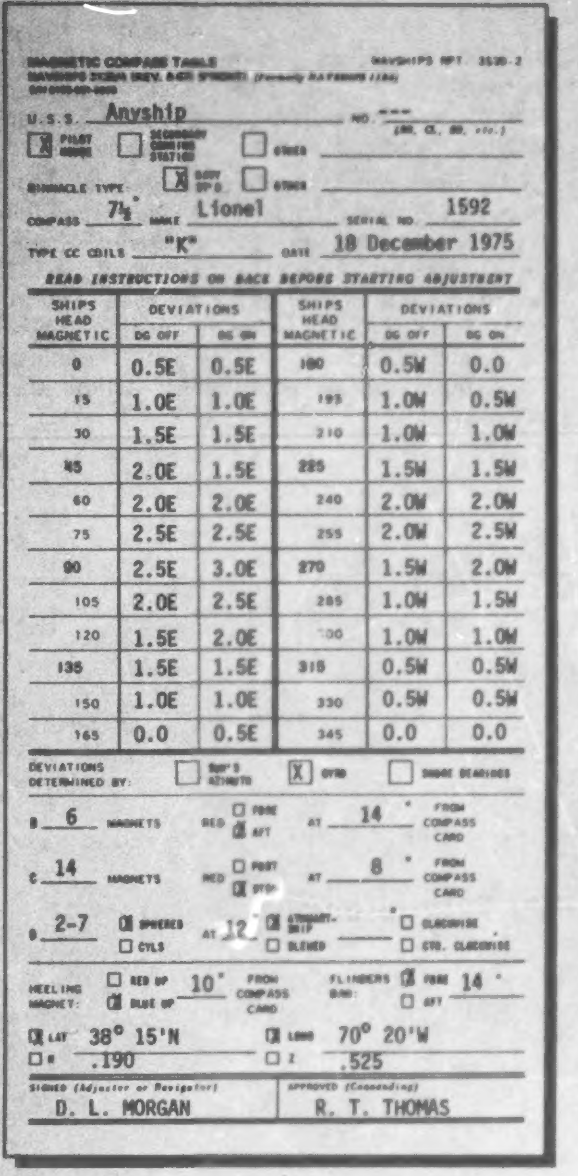
Most standard types of compass compensating coils are composed of an enclosure, a single heeling coil to compensate the vertical component, and two coils or two pairs of coils to compensate the cardinal or intercardinal components. Each coil consists of a number of windings, one winding for each degaussing coil which produces at the compass a magnetic field that must be compensated. Compass compensating coils usually are installed and compensated for degaussing by personnel at a naval shipyard or a degaussing activity.

The compass compensating coils operate automatically when the degaussing coils are turned on. This operation is easily understandable when it is known that the power supply used for the compensating coils usually is the voltage drop across a number of turns of the degaussing coil. Thus, a change in the current in a degaussing coil automatically affects the compensating coils, ensuring that the compass compensation is undisturbed. Operation should be checked once a week, preferably at the time the degaussing coils are energized to dry out the cables. It should be noted at that time whether any compass deviations in excess of allowable limits are produced when the degaussing coils are turned on or off.

Because one of the foremost responsibilities of a Quartermaster is to know all about his ship's magnetic compasses, it is imperative that he also have a working knowledge of the degaussing equipment installed on his ship. The best single source of this information is the ship's degaussing folder. You should study this folder and understand it thoroughly before you assume your first watch at sea.

MAGNETIC COMPASS TABLE

In figure 4-10 you see the prepared form in general use for recording deviations (NAVSHIPS Form 3120/4). On the form the deviations for every 15 ° around the compass are shown. Note that deviations are recorded in two columns headed DG OFF and DG ON. The deviations in



MAGNETIC COMPASS TABLE

U.S.S. Anyship NO. ---

☒ PILOT HOUSE ☐ SECONDARY CONNING STATION ☐ OTHER

BINNACLE TYPE ☒ ☐ OTHER

COMPASS 7½" MAKE Lionel SERIAL NO. 1592

TYPE CC COILS "K" DATE 18 December 1975

READ INSTRUCTIONS ON BACK BEFORE STARTING ADJUSTMENT

SHIPS HEAD MAGNETIC	DEVIATIONS		SHIPS HEAD MAGNETIC	DEVIATIONS	
	DG OFF	DG ON		DG OFF	DG ON
0	0.5E	0.5E	180	0.5W	0.0
15	1.0E	1.0E	195	1.0W	0.5W
30	1.5E	1.5E	210	1.0W	1.0W
45	2.0E	1.5E	225	1.5W	1.5W
60	2.0E	2.0E	240	2.0W	2.0W
75	2.5E	2.5E	255	2.0W	2.5W
90	2.5E	3.0E	270	1.5W	2.0W
105	2.0E	2.5E	285	1.0W	1.5W
120	1.5E	2.0E	300	1.0W	1.0W
135	1.5E	1.5E	315	0.5W	0.5W
150	1.0E	1.0E	330	0.5W	0.5W
165	0.0	0.5E	345	0.0	0.0

DEVIATIONS DETERMINED BY: ☐ SUN'S AZIMUTH ☒ GYRO ☐ SHORE BEARINGS

B 6 MAGNETS RED ☐ FORE ☒ AFT AT 14" FROM COMPASS CARD

C 14 MAGNETS RED ☐ PORT ☒ STBD AT 8" FROM COMPASS CARD

D 2-7 ☒ SPHERES ☐ CYLS AT 12" ☒ ATHWARTSHIP ☐ SLEWED ☐ CLOCKWISE ☐ CTR. CLOCKWISE

HEELING MAGNET: ☐ RED UP ☒ BLUE UP 10" FROM COMPASS CARD FLINDERS BAR: ☒ FORE ☐ AFT 14"

☒ LAT 38° 15'N ☒ LONG 70° 20'W

☐ H .190 ☐ Z .525

SIGNED (Adjuster or Navigator) D. L. MORGAN

APPROVED (Commanding) R. T. THOMAS

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Figure 4-10.—Magnetic compass table.

the first column were recorded with the ship's degaussing system secured. For the second column, readings were taken with the ship's degaussing system energized. Whether the degaussing system is on or off may cause a considerable difference in the deviation; hence each condition must have a separate column. In correcting or uncorrecting, it is important that you use the deviation for the proper condition of the ship's degaussing system.

To compute the deviation on any magnetic heading not given in the table, it is necessary to interpolate between the two nearest recorded readings. If the deviations recorded on each 15° heading do not vary by more than ½° from the adjacent readings, you may use the deviation for the heading nearest the one you are checking.

GYROCOMPASS

The gyrocompass is unaffected by either variation or deviation. When in proper running order, it points constantly to the true rather than the magnetic north pole. It may have a slight mechanical error, but this error is computed easily and remains constant for any heading so that it does not interfere in any way with the instrument's practical value.

Considering the gyro's advantage, you may wonder why the Navy doesn't heave all the magnetic compasses over the side and relieve Quartermasters of the necessity for learning the principles of correcting magnetic compass error. The answer is that, despite the excellence of the gyromechanism, it is the magnetic compass, not the gyrocompass, that is standard aboard ship. The reason is simple: The magnetic compass operates through the attraction exerted by that great natural magnet, the Earth. The Earth is absolutely certain to continue to function as a magnet; therefore, the magnetic compass will never go out of commission because of any failure of its source of power.

The gyrocompass, on the other hand, is powered by electricity. Cut off the supply, and the gyro is absolutely useless. Being an extremely complicated and delicate instrument, it also is subject to mechanical failure. Some gyros, for instance, become erratic after a ship makes a series of sharp turns at high speed. These disadvantages do not mean, however, that great confidence cannot be placed in the gyro. It can be depended upon, when running properly, to point faithfully and steadily to true North. But it is the magnetic compass that always remains the reliable standby, constantly checking the gyro's performance and ready at all times to take over if the gyro fails.

The principles on which the gyro functions are too complicated for short explanation. Operation of its delicate mechanism is the responsibility of the IC gang.

MASTER GYROS AND GYRO REPEATERS

A typical shipboard installation consists of one or more master gyros, whose indications are transmitted electrically to repeaters. The gyro repeaters are located in the conning stations, on the bridge wings, and at other points as may be necessary.

A chief advantage of the gyro is that its repeaters may be set up any angle—nearly on edge for the convenience of steersman, or flat for taking bearings.

The master gyro should be started at least 4 hours before getting underway to allow time for it to settle before use. The quartermaster on watch must check to see that the gyro is started, that the time is entered in the deck log. He also must check its performance frequently against the standard compass. Additionally, he must check the repeaters occasionally against the master gyro.

CHAPTER 5

AIDS TO NAVIGATION

One branch of navigation is piloting, in which a ship's position is determined by bearings taken on visible objects whose exact locations are shown on a chart. Some of the objects may be natural, such as hills, isolated rocks, or points of land. Others are manmade, such as large buildings, smokestacks, TV towers, etc., which are coincidentally located where they can be of assistance to navigators.

Aids to navigation are lighthouses, lightships, minor lights, buoys, and day beacons. Aids are placed so that, insofar as possible, they provide a continuous and unbroken chain of charted marks for coast and channel piloting. The extent to which the system of aids is complete and accurate depends upon the status of the particular country as a maritime power.

Most harbors and frequented coasts are well marked with manmade aids to navigation, yet no attempt has ever been made to so mark every mile of the world's coastlines. Such marking would be impractical because many regions are seldom navigated. In some areas the lack of artificial aids (together with knowledge that artificial aids may be inoperative, out of position, or completely destroyed) frequently makes the use of landmarks necessary.

Learning to observe and plot bearings of landmarks may, at first, be more difficult than learning to take and plot bearings of manmade aids. But whenever landmarks must be used, the effort applied to learning pays huge dividends in accuracy of position and safety. Landmarks may be used at any time, provided they are distinguishable by the navigator and identifiable on his chart. Further information on the use of landmarks is given in the chapter on piloting.

LIGHTS

A ship cannot suspend piloting operations merely because darkness falls and daytime aids cannot be distinguished. For that reason, aids to navigation are lighted whenever it is both necessary and practicable. For purposes of identification, lights have individual characteristics regarding color, brilliancy and system of operation. Some of a light's characteristics may be printed near its symbol on the chart. Detailed information, including the height—which, combined with brilliancy and observer's height, determines a light's visibility—is set forth in light lists.

The Defense Mapping Agency Hydrographic Center publishes a List of Lights in seven volumes divided geographically (excluding the United States and its possessions). This list contains a description of lighted navigational aids (except harbor lighted buoys) and fog signals. Storm signals, signal stations, radio direction finders and radio beacons located at or near lights are also mentioned in this list.

Lights located in the United States and its possessions are described in Light Lists published by the U.S. Coast Guard.

LIGHT CHARACTERISTICS

White, red, and green are the three standard colors for lights on aids to navigation. Significance of the colors is important chiefly regarding channel buoys. They are discussed in the section devoted to buoys.

Fixed, Flashing, and Occulting

Some navigational lights are fixed, meaning that they burn steadily. Most important lights, however, go through repeated periods of systematic changes of light and darkness. It is this phase characteristic of a navigational light that is the most valuable for identification purposes.

Figure 5-1 illustrates the principal characteristic of lights on lighthouses and lightships. Lighted buoys have a few more special characteristics which are mentioned later.

VISIBILITY OF LIGHTS

The visibility of lights is the specific distance, in nautical miles, a navigator can expect to see a navigational aid such as a lighthouse, lightship, or beacon.

In speaking of the visibility of a light, the following terms are applicable:

1. Geographic range: Maximum calculated distance at which the curvature of the Earth permits a light to be seen from a height of eye of 15 feet above the water when the elevation of the light is taken above the height datum of the largest scale chart of the locality.
2. Nominal range: Maximum distance at which a light can be seen in clear weather, which is meteorologically defined as a visibility of 10 nautical miles. Nominal range is listed for all Coast Guard listed aids except range and direction lights.
3. Luminous range: Maximum distance at which a light can be seen under the existing meteorological visibility conditions. It depends only on the intensity of the light itself and is independent of the elevation of the light, observer's height of eye, or the curvature of the Earth.
4. Computed visibility: Determined for a particular light, taking into account its elevation, intensity, height of eye of the observer, and the curvature of the Earth.

In computing visibility of a light, it is assumed that computed visibility never will exceed the light's luminous range or the computed range although, under certain atmospheric conditions, the loom or glare of a powerful light may appear before the light itself is visible.

The following examples illustrate the recommended procedure for determining the visibility of a light. Bear in mind that computed visibility cannot be greater than the luminous range.

Example 1: Determine the visibility of Light Alpha for an observer with a height of eye of 50 feet.

Solution: From the light list, determine the nominal range (20 miles) and the height of the light above water (90 feet).

Determine horizon distance from the table of distance of visibility of objects of various elevations above sea level (table 5-1). and place in form shown below.

Height of eye of 50 feet	8.1 miles
Height of light above water, 90 feet	10.9 miles
Computed visibility	19.0 miles
Nominal range	20.0 miles

Answer: 19.0 miles

Example 2: Determine the visibility of Light Bravo for an observer with height of eye of 37 feet.

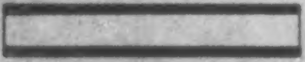
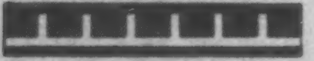
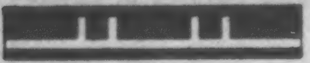
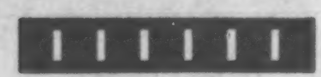
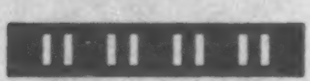
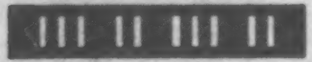
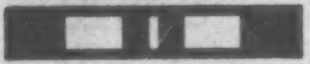
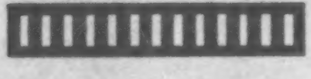
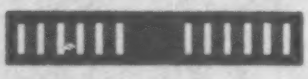
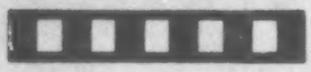
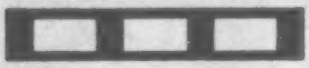
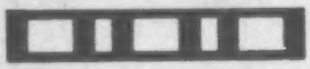
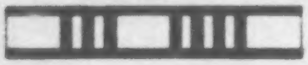
Solution: From Light List, determine the nominal range (10 miles) and the height of the light above water (77 feet). Determine horizon distance from table 5-1, interpolating for 77 feet.

Height of eye for 37 feet	7.0 miles
Height of light above water , 77 feet	10.0 miles
Computed visibility	17.0
Nominal range	10.0

Answer: 10 miles

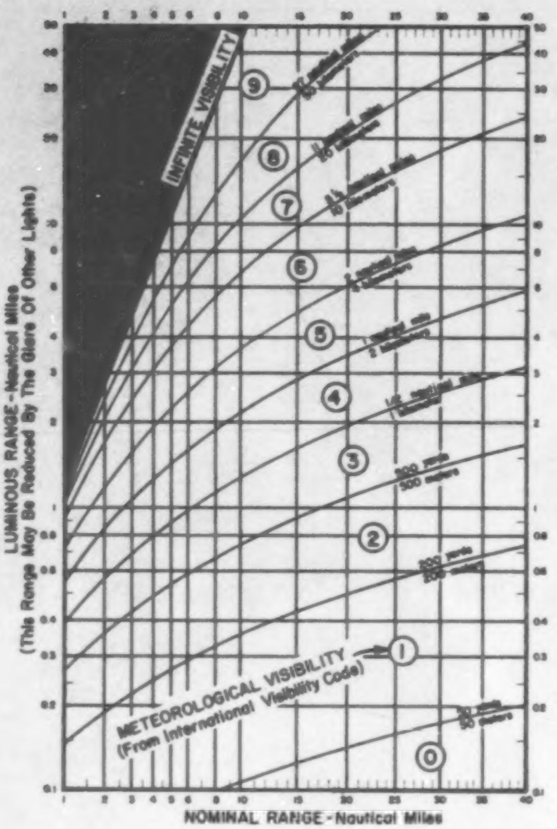
Luminous Range Diagram

The luminous range diagram (figure 5-2) enables the mariner to determine the approximate range at which a light may be

Illustrations	Symbols and meaning		Phase description
	Lights which do not change color	Lights which show color variations	
	**F.**=Fixed-------	**Alt.**=Alternating.	A continuous steady light.
	**F.Fl.**=Fixed and flashing.	**Alt.F.Fl.**=Alternating fixed and flashing.	A fixed light varied at regular intervals by a single flash of greater brilliance.
	**F.Gp.Fl.**=Fixed and group flashing.	**Alt.F.Gp.Fl.**=Alternating fixed and group flashing.	A fixed light varied at regular intervals by groups of 2 or more flashes of greater brilliance. The group may, or may not, be preceded and followed by an eclipse.
	**Fl.**=Flashing----	**Alt.Fl.**=Alternating flashing.	Showing a single flash at regular intervals, the duration of light always being less than the duration of darkness.
	**Gp.Fl.**=Group flashing.	**Alt.Gp.Fl.**=Alternating group flashing.	Showing at regular intervals groups of 2 or more flashes.
	**Gp.Fl.(3+2)**= Composite group flashing.	---------------	Group flashing in which the flashes are combined in alternate groups of different numbers.
	**Mo.(K)**=Morse Code.	---------------	Light in which flashes of different durations are grouped to produce a Morse *character* or *characters*.
	**Qk.Fl.**=Quick flashing.	---------------	Shows not less than 60 flashes per minute.
	**Int.(I.)Qk.Fl.**= Interrupted quick flashing.	---------------	Shows quick flashes for about 4 seconds, followed by a dark period of about 4 seconds.
	**Iso.(E.Int.)** **Isophase.**	---------------	Duration of light equal to that of darkness.
	**Occ.**=Occulting.	**Alt.Occ.**=Alternating occulting.	A light totally eclipsed at regular intervals, the duration of light always greater than the duration of darkness.
	**Gp.Occ.**=Group occulting.	**Alt.Gp.Occ.**=Alternating group occulting.	A light with a group of 2 or more eclipses at regular intervals.
	**Gp.Occ.(3+4)**= Composite group occulting.	---------------	Group occulting in which the occultations are combined in alternate groups of different numbers.

Light colors used and abbreviations: W=white, R=red, G=green.

Figure 5-1.—Typical light characteristics 69.22



69.23

Figure 5-2.—Luminous range diagram.

sighted at night in the meteorological (pertaining to weather) visibility prevailing at the time of observation.

The diagram is entered from the top or bottom border, using the nominal range obtained from Light List. The figures along the curves represent the estimated meteorological visibility at the time of observation, and those along the left-hand border represent the luminous range under those conditions.

Example: A light has a nominal range of 20 miles. If the meteorological visibility (along the curved line) is 20 miles, the light would be sighted at about 33 miles; with 5 miles meteorological visibility, the luminous range of the light is about 12 miles.

Table 5-1.—Distance of Visibility of Objects of Various Elevations Above Sea Level

HEIGHT IN FEET	DISTANCE IN GEOGRAPHIC OR NAUTICAL MILES	HEIGHT IN FEET	DISTANCE IN GEOGRAPHIC OR NAUTICAL MILES
1	1.1	45	7.7
2	1.6	46	7.8
3	2.0	47	7.8
4	2.3	48	7.9
5	2.6	49	8.0
6	2.8	50	8.1
7	3.0	55	8.5
8	3.2	60	8.9
9	3.4	65	9.2
10	3.6	70	9.6
11	3.8	75	9.9
12	4.0	80	10.2
13	4.1	85	10.5
14	4.3	90	10.9
15	4.4	95	11.2
16	4.6	100	11.4
17	4.7	105	11.7
18	4.9	110	12.0
19	5.0	115	12.3
20	5.1	120	12.5
21	5.2	125	12.8
22	5.4	130	13.0
23	5.5	135	13.3
24	5.6	140	13.5
25	5.7	145	13.8
26	5.8	150	14.0
27	5.9	160	14.5
28	6.1	170	14.9
29	6.2	180	15.3
30	6.3	190	15.8
31	6.4	200	16.2
32	6.5	210	16.6
33	6.6	220	17.0
34	6.7	230	17.3
35	6.8	240	17.7
36	6.9	250	18.1
37	7.0	260	18.4
38	7.1	270	18.8
39	7.1	280	19.1
40	7.2	290	19.5
41	7.3	300	19.8
42	7.4	310	20.1
43	7.5	320	20.5
44	7.6	330	20.8

69.130

CAUTION: When using this diagram, it must be remembered that:

1. The ranges obtained are approximate.
2. The transparency of the atmosphere is not necessarily consistent between the observer and the light.
3. Glare from background lighting will reduce considerably the range at which lights are sighted.

LIGHTHOUSES AND LIGHT STRUCTURES

Lighthouses are numerous on all coasts of the United States, on the Great Lakes, and along many interior waterways. They are placed wherever a powerful light may be of assistance to navigators or wherever a danger requires a warning beacon of long-range visibility. Visibility increases with height on a powerful light; hence the principal purpose of a light structure is to increase the height of a light above sea level.

NOTE: It should be remembered that a light placed at a great elevation is more frequently obscured by clouds, mist, and fog than one near sea level.

A lighthouse may also contain fog-signaling and radio beacon equipment. Many lights formerly operated by keepers are now automatic. In lighthouses still staffed by keepers, the lighthouse also may contain their living quarters. When operating personnel are housed in separate buildings grouped around the tower, the group of buildings is called a light station.

Secondary, minor, and automatic lights are located in structures ranging from towers that resemble important seacoast lighthouses down to a small cluster of piles supporting a battery box and lens.

Solid colors, bands, stripes, and other color patterns are applied to lighthouses and light structures as an aid to identification. (See figure 5-3). Minor structures sometimes are painted red or black, like channel buoys, to indicate the side of the channel on which they are located—red structures to the right, black to the left, returning from seaward.

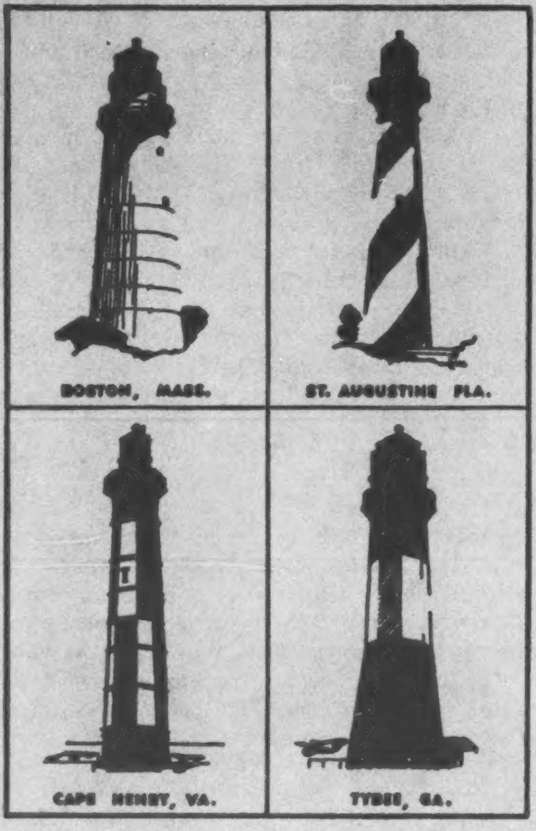

BOSTON, MASS.
ST. AUGUSTINE FLA.
CAPE HENRY, VA.
TYBEE, GA.
69.24

Figure 5-3.—Various patterns of typical lighthouses.

LIGHTSHIPS

A lightship is a floating lighthouse, located where conditions make it impossible or impracticable to build a permanent structure.

Lightships in United States waters are painted red on the hull, with the name of the station in large white letters on either side. Superstructures are painted white; masts, lantern galleries, ventilators, and stacks are buff.

The lights, fog signals, and radio beacon signals on lightships are given various characteristics for purposes of identification. Like lighthouses, lightships are described briefly on the chart and in detail in light lists.

A lightvessel underway or offstation hoists the International Code signal "LO", signifying that the lightvessel is not in correct position. She must then observe the requirements of the Rules of the Road for a vessel of her class.

When anchored on station, a lightship at night shows only her beacon light(s) and a less brilliant light on the forestay to indicate her heading.

When a regular lightship goes in for overhaul or repairs, her place is taken by a relief lightship whose lights and signals have, as nearly as possible, the same characteristics as the regular lightship. Relief lightships are distinguished by the word "RELIEF" painted in white letters on either side.

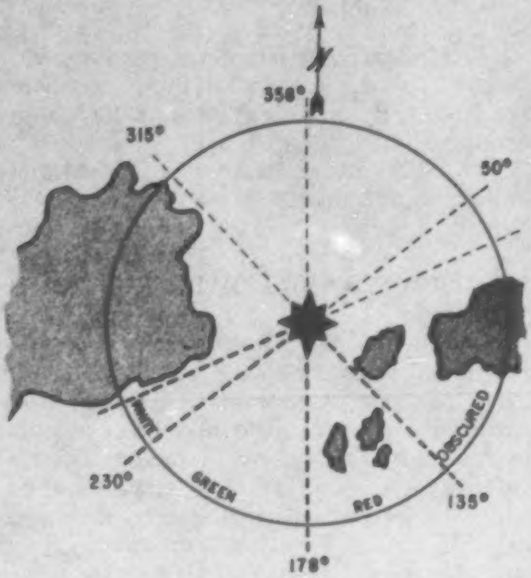
DANGER SECTORS

Sectors of red glass are placed in the lanterns of certain lighthouses to indicate danger bearings within which a ship will be in danger of running on rocks, shoals, or some other hazard. The arcs over which the red light shows are the danger sectors whose bearings usually appear on the chart. Although the light is red within the danger bearings, its other characteristics remain the same.

Sectors may be only a few degrees in width, marking an isolated obstruction, or they may be so wide that they extend from the direction of deep water to the beach. In most instances, red sectors indicate water to be avoided. A narrow green sector may signify a turning point or the best water across a shoal. Exact significance of each sector may be obtained from the chart.

All sector bearings are true bearings in degrees, running clockwise around the light as a center. In figure 5-4, for instance, the bearings of the red sector from the light are 135° to 178°. This sector is defined in the light list in terms of bearings from the ship. These bearings are 315° to 358°, the reciprocals of the preceding bearings. The light shown in the diagram would be defined thus: Obscured from land to 315°, red thence to 358°, green thence to 050°, white thence to land.

On either side of the line of demarcation between colored and white sectors, there is always a small sector whose color is doubtful because the edges of a sector cannot be cut off sharply in color. Under some atmospheric conditions, moreover, a white light itself may have a reddish appearance. Consequently, light sectors must not be relied upon entirely; but position must be verified repeatedly by bearings taken on the light itself or by other fixed objects.



69.25

Figure 5-4.—Light sectors.

When a light is cut off by adjoining land, the arc of visibility may vary with a ship's distance away from the light. If the intervening land is sloping, for example, the light may be visible over a wider arc from a far-off ship than from one close inshore.

BUOYS

Navigational buoys are moored floating markers, placed so as to guide ships in and out of channels, warn them away from hidden dangers, lead them to anchorage areas, etc. Buoys may be of various sizes and shapes (figure 5-5). Regardless of their shapes, however, their distinctive coloring is the chief indication of their purposes.

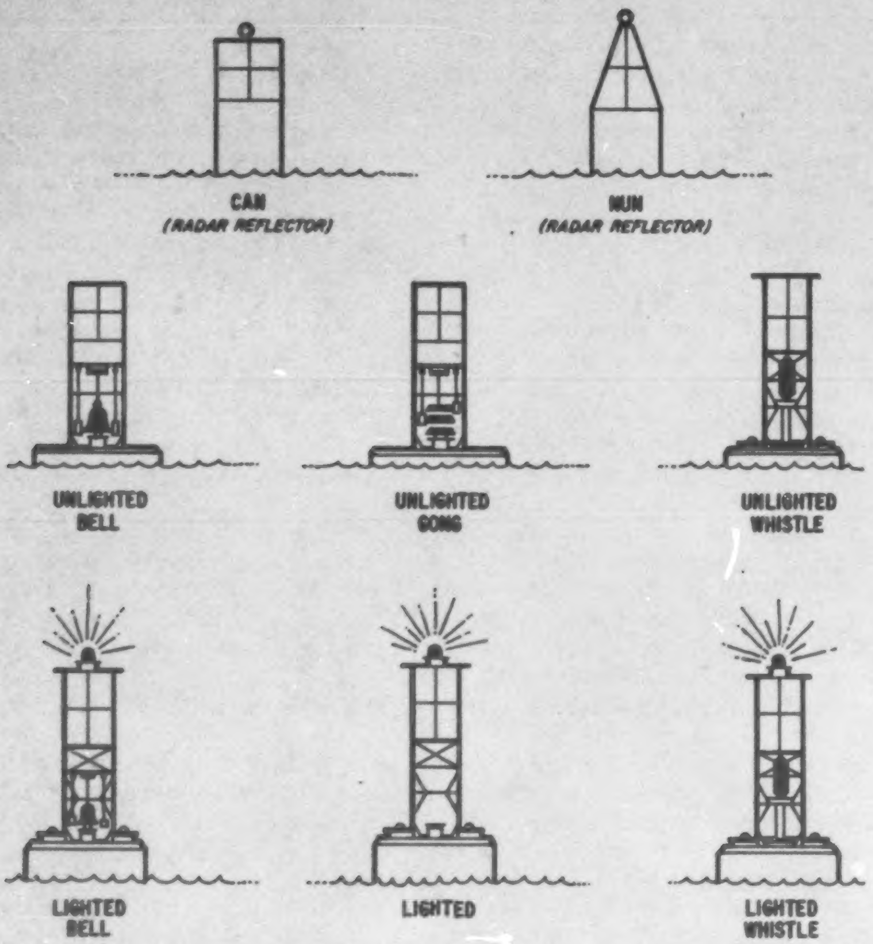

CAN
(RADAR REFLECTOR)
NUN
(RADAR REFLECTOR)
UNLIGHTED
BELL
UNLIGHTED
GONG
UNLIGHTED
WHISTLE
LIGHTED
BELL
LIGHTED
LIGHTED
WHISTLE
17.33

Figure 5-5.—Types of United States buoys.

TYPES OF BUOYS

Although a buoy's type has no special navigational significance, it may help toward its identification from the description given on the chart. The following are the principal types of buoys.

1. Spar buoys are large logs, trimmed, shaped, and appropriately painted. They also may be of metal, constructed in the familiar spar shape.

2. Can and nun buoys are cylindrical and conical, respectively.

3. A bell buoy has a flat top, surmounted by a framework supporting a bell. Older bell buoys are sounded by the motion of the sea. Newer types are operated automatically by compressed gas or electricity.

4. A gong buoy is similar to a bell buoy except that it has a series of gongs, each with a different tone.

5. A whistle buoy is similar to a bell buoy except it carries a whistle sounded by the sea's

motion, or horns that are sounded at regular intervals by mechanical or electrical means.

6. A lighted buoy carries batteries or gas tanks, and is surmounted by a framework supporting a light. (A description of the lights on lighted buoys is given later.)

7. A combination buoy is one in which a light and sound signal are combined, such as a lighted bell, gong, or whistle buoy.

COLORING OF BUOYS

In the United States red buoys mark the right side, and black buoys the left side of the channel, coming from seaward. A great help in remembering this placement of buoys is the jingle "red right returning."

Normally, red channel buoys are cone-shaped nun buoys whereas black channel buoys are cylindrical can buoys. This situation probably is the only one in which a buoy's shape is of any significance, and even here the rule is not controlling. Either can buoys or nun buoys may be replaced with spar buoys of proper color. It is the color that counts. Sometimes red and black buoys are painted white on top, but this color scheme is merely to enable them to be located more easily at night.

Red and black horizontally banded buoys mark junctions in the channel, or wrecks or obstructions which may be passed on either side. If the topmost band is black, the preferred channel will be followed by keeping the buoy on the port (left) hand. If the topmost band is red, the preferred channel will be followed by keeping the buoy on the starboard (right) hand.

NOTE: When proceeding toward seaward, it may not be possible to pass on either side of these buoys, and the chart should always be consulted.)

Black and white vertically striped buoys mark the middle of a channel or fairway. Yellow buoys mark quarantine anchorages.

The foregoing conditions are practically all the colors on buoys that have a direct connection with navigation. Buoys painted all white have no special significance; they are utilized for purposes not concerned with navigation, such as marking ordinary anchorage areas. Buoys with black and white horizontal stripes are used in some locales to mark fishtrap areas. A white buoy with a green top usually means a dredging area.

NUMBERS ON BUOYS

The red buoys marking the right side of a channel bear even numbers, starting with the first buoy from seaward. This maritime situation is, perhaps , the only one in which anything to starboard has an even number. Black channel buoys, to the left of the channel coming from seaward, have odd numbers. Both the number and one or two letters appear on some channel buoys; e.g., the Governor's Island (New York harbor) West End Shoal Bell Buoy. Because it is the first buoy on the port side of the channel coming from seaward, it is painted black and carries the number 1. The letters GI are painted next to the 1.

Banded or striped buoys are not numbered, but some have letters for identification purposes. For example, the East Rockaway Inlet Bell Buoy (vertical black and white stripes) carries the letters ER.

LIGHTS ON BUOYS

Red lights are used only on red buoys or red and black horizontally banded buoys, with the topmost band red. Green lights are only for black buoys or black and red horizontally banded buoys, with the topmost band black. When a light of considerable brilliance is required, a white light frequently is substituted for either the green or the red light. White lights are the only lights used on the black and white vertically striped buoys that mark the middle of a channel of fairway. Characteristics of lights on lighted buoys follow.

1. A fixed (steady) light means either a black or red channel buoy.

2. A flashing light (at regular intervals, not more than 30 flashes per minute) may also mean either a black or red buoy.

3. A quick-flashing light (no fewer than 60 flashes per minute) is also on either a black or red buoy, but at a turning point or junction where special caution is required.

4. An interrupted quick-flashing light (*repeated series of quick flashes, separated by* about 4-second dark intervals) indicates a red and black horizontally banded obstruction buoy.

5. A short-long flashing light (short and a long flash, recurring at the rate of about 8 per minute) is placed on a black and white vertically striped midchannel buoy.

FALLIBILITY OF BUOYS

Although buoys are valuable aids to navigation, they must never be depended upon exclusively. Buoys frequently drag their moorings in heavy weather, or they may be set adrift when run down by passing vessels. Lights on lighted buoys may go out of commission. Whistles, bells, and gongs actuated by the sea's motion may fail to function in smooth water.

DAYBEACONS

Unlighted aids to navigation (except unlighted buoys) are called daybeacons. A daybeacon may consist of a single pile with a daymark on top of it, a spar supporting a cask, a slate or masonry tower, or any of several structures.

Daybeacons, like lighthouses and light structures, usually are colored to distinguish them from their surroundings and make them easy to identify. Daybeacons marking channels are colored and numbered like channel buoys. Many are fitted with reflectors that show the same colors a lighted buoy would show at night in the same position.

RANGES

Two daybeacons, located some distance apart on a specific true bearing, constitute a daybeacon range. Two lights, similarly located, are a lighted range. When a ship reaches a position where the two lights or beacons are seen exactly in line, she is "on the range." Ranges are especially valuable for guiding ships along the approaches to or through narrow channels. Much steering through the Panama Canal is accomplished on ranges. Other examples *of successive straight reaches marked* by ranges are the channel entrances to the St. John's River, on the Atlantic coast, and to the Columbia River on the Pacific coast.

Lights on ranges may show any of the three standard colors, and they may be fixed, flashing, or occulting. Most range lights appear to lose brilliance rapidly as a ship diverges from the range line of bearing.

When steering on a range, it is highly important to ascertain the limit beyond which the range line of bearing cannot be followed safely. This information is available on the chart.

FOG SIGNALS

Most lighthouses and lightships are equipped with installed fog-signaling apparatus, ordinarily sounded automatically by mechanical means. For identification purposes, each station has its own assigned number of blasts, recurring at specified intervals. A definite time is required for each station to sound its entire series of blasts, and this timing provides another means of identification.

The various types of apparatus produce corresponding variance of pitch and tone, thus giving your ear a chance to compare the sound of a station with its description in the light list.

AIDS IN INTRACOASTAL WATERWAY

The Intracoastal Waterway, called the inland waterway, is a channel in which a light-draft vessel can navigate coastwise from the Chesapeake Bay almost to the Mexican border, remaining inside natural or artificial breakwaters for almost the entire length of the trip. Ensuing paragraphs describe special markings for the Intracoastal Waterway proper and for those portions of connecting or intersecting waterways that must be crossed or followed in navigating it.

Every buoy, daybeacon, or light structure along the Intracoastal Waterway has part of its surface painted yellow, the distinctive coloring adopted for this Waterway. Lighted buoys have a band or border of yellow somewhere.

Red buoys and daybeacons are to the right, black to the left, as you proceed from the Chesapeake Bay toward Mexico. As in other channels, red buoys have even numbers; black buoys, odd numbers. Because the numbers would increase excessively in such a long line of buoys, they are numbered in groups that usually contain no more than 200 buoys. At certain natural dividing points, numbering begins again at 1.

Lights on buoys in the Intracoastal Waterway follow the standard system of red or white lights on red buoys, and green or white lights on black buoys. Lights on lighted aids besides buoys also agree with the standard rules for lights on aids to navigation.

LATERAL AND CARDINAL BUOYAGE SYSTEMS

Most maritime countries use either the lateral or the cardinal system of buoyage; some regions use both. In the lateral system (figure 5-6), used on all navigable waters of the United States, the coloring, shape, and lighting of buoys indicate the direction to a danger relative to the course that should be followed. In the cardinal buoyage system (figure 5-7), the coloring, shape, and lighting of buoys show the cardinal direction to a danger relative to the buoy itself. The color, shape, lights, and number of buoys in the lateral system, as used by the United States, are determined relative to a direction from seaward. Some countries using the lateral system color their buoys and lights the direct opposite of the United States color scheme. Before going into foreign waters, consult Sailing Directions for an exact description of the aids to navigation in the particular locality.

In offshore channels, the lateral buoyage system prescribes the following markings and colorings for United States waters: Proceeding in a southerly direction along the Atlantic coast, in a northerly and westerly direction along the Gulf coast, and in a northerly direction along the Pacific coast is considered to be proceeding from seaward. Accordingly, coastal buoys on the right, when proceeding in those directions, are red buoys with even numbers. On the Great Lakes, offshore buoys are colored and numbered from the outlet of each lake toward its upper end. The Intracoastal Waterway is marked from the North Atlantic States to the lower coast of Texas, regardless of the compass bearings of individual sections.

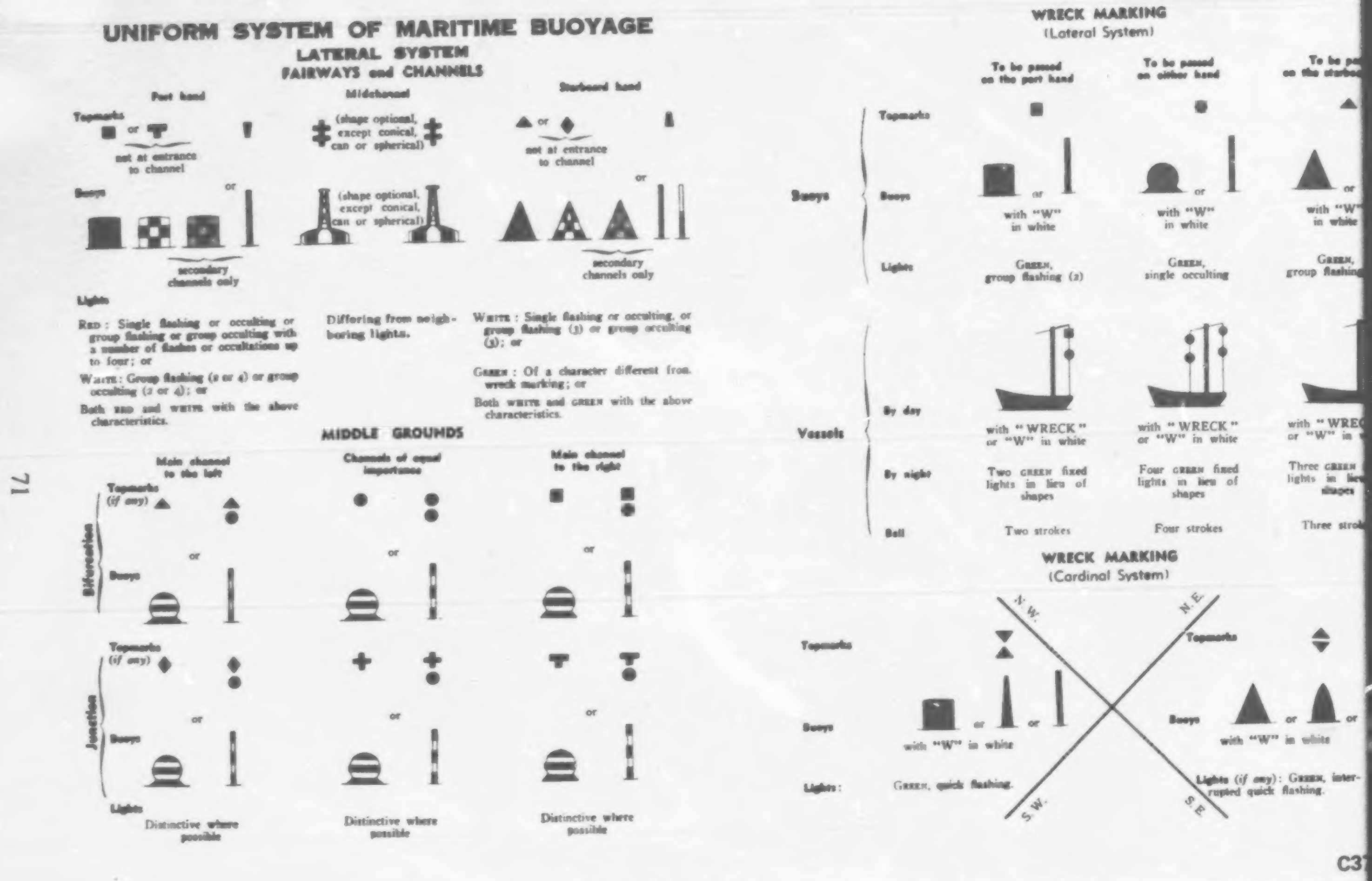
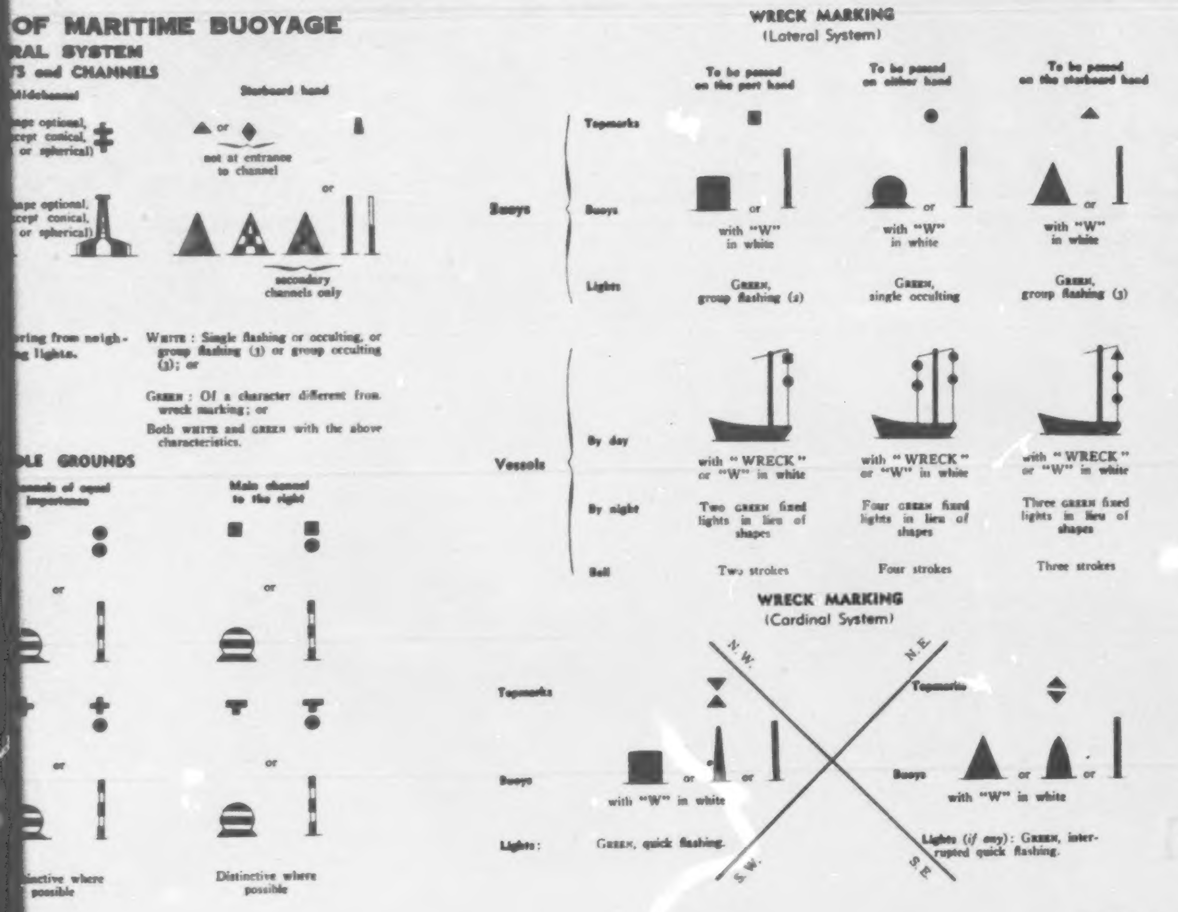
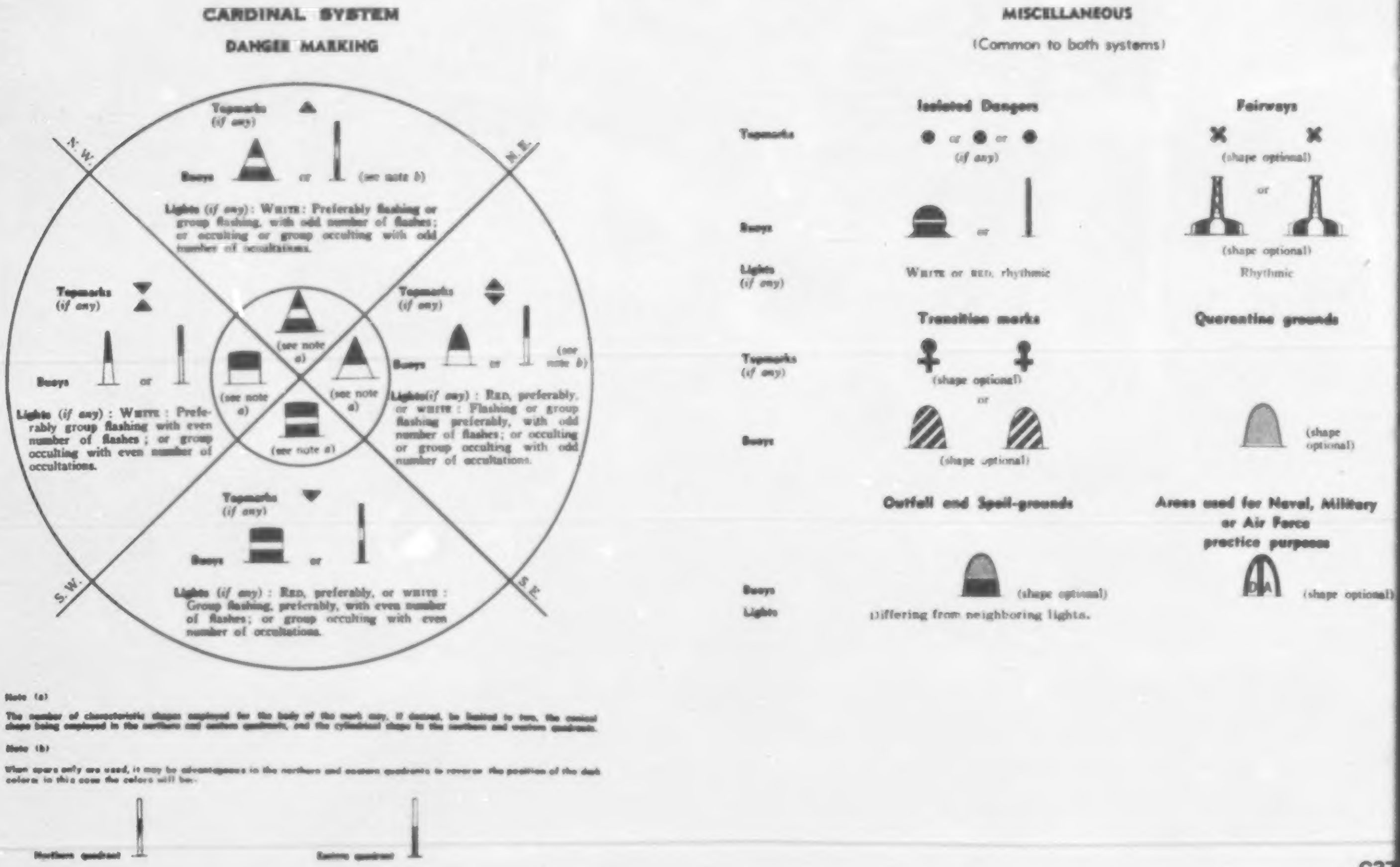

UNIFORM SYSTEM OF MARITIME BUOYAGE
LATERAL SYSTEM
FAIRWAYS and CHANNELS
Port hand
Midchannel
Starboard hand
Topmarks
or
not at entrance to channel
(shape optional, except conical, can or spherical)
Buoys
secondary channels only
Lights
Red: Single flashing or occulting or group flashing or group occulting with a number of flashes or occultations up to four; or
White: Group flashing (2 or 4) or group occulting (2 or 4); or
Both red and white with the above characteristics.
Differing from neighboring lights.
White: Single flashing or occulting, or group flashing (3) or group occulting (3); or
Green: Of a character different from wreck marking; or
Both white and green with the above characteristics.
MIDDLE GROUNDS
Main channel to the left
Channels of equal importance
Main channel to the right
Topmarks (if any)
Bifurcation
Junction
Buoys
Lights
Distinctive where possible
71
WRECK MARKING
(Lateral System)
To be passed on the port hand
To be passed on either hand
To be passed on the starboard hand
Topmarks
Buoys
with "W" in white
Lights
Green, group flashing (2)
Green, single occulting
Green, group flashing
Vessels
By day
with "WRECK" or "W" in white
By night
Two green fixed lights in lieu of shapes
Four green fixed lights in lieu of shapes
Three green lights in lieu of shapes
Bell
Two strokes
Four strokes
Three strokes
WRECK MARKING
(Cardinal System)
N.W.
N.E.
S.W.
S.E.
Topmarks
Buoys
with "W" in white
Lights:
Green, quick flashing.
Lights (if any): Green, interrupted quick flashing.
C37

Figure 5-6.—Lateral buoyage system.


OF MARITIME BUOYAGE
RAL SYSTEM
TS and CHANNELS
Midchannel
ape optional,
cept conical,
or spherical)
ape optional,
cept conical,
or spherical)
Starboard hand
or
not at entrance
to channel
or
secondary
channels only
ring from neigh-
g lights.
WHITE : Single flashing or occulting, or
group flashing (3) or group occulting
(3); or
GREEN : Of a character different from
wreck marking; or
Both WHITE and GREEN with the above
characteristics.
LE GROUNDS
annels of equal
importance
Main channel
to the right
or
or
or
or
inctive where
possible
Distinctive where
possible
WRECK MARKING
(Lateral System)
To be passed
on the port hand
To be passed
on either hand
To be passed
on the starboard hand
Buoys
Topmarks
Buoys
or
or
or
with "W"
in white
with "W"
in white
with "W"
in white
Lights
GREEN,
group flashing (2)
GREEN,
single occulting
GREEN,
group flashing (3)
Vessels
By day
with " WRECK "
or "W" in white
with " WRECK "
or "W" in white
with " WRECK "
or "W" in white
By night
Two GREEN fixed
lights in lieu of
shapes
Four GREEN fixed
lights in lieu of
shapes
Three GREEN fixed
lights in lieu of
shapes
Bell
Two strokes
Four strokes
Three strokes
WRECK MARKING
(Cardinal System)
N.W.
N.E.
S.W.
S.E.
Topmarks
Topmarks
Buoys
or
or
with "W" in white
Buoys
or
or
with "W" in white
Lights:
GREEN, quick flashing.
Lights (if any): GREEN, interrupted quick flashing.

C37.23:24

Figure 5-6.—Lateral buoyage system.


CARDINAL SYSTEM
DANGER MARKING
N.W.
N.E.
S.W.
S.E.
Topmarks (if any)
Buoys
or
(see note b)
Lights (if any): WHITE: Preferably flashing or group flashing, with odd number of flashes; or occulting or group occulting with odd number of occultations.
Topmarks (if any)
Buoys
or
Lights (if any): WHITE: Preferably group flashing with even number of flashes; or group occulting with even number of occultations.
Topmarks (if any)
Buoys
or
(see note b)
Lights (if any): RED, preferably, or WHITE: Flashing or group flashing preferably, with odd number of flashes; or occulting or group occulting with odd number of occultations.
(see note a)
(see note a)
(see note a)
(see note a)
Topmarks (if any)
Buoys
or
Lights (if any): RED, preferably, or WHITE: Group flashing, preferably, with even number of flashes; or group occulting with even number of occultations.
MISCELLANEOUS
(Common to both systems)
Isolated Dangers
Fairways
Topmarks
or
or
(if any)
(shape optional)
or
Buoys
or
(shape optional)
Lights (if any)
WHITE or RED, rhythmic
Rhythmic
Transition marks
Quarantine grounds
Topmarks (if any)
(shape optional)
or
Buoys
(shape optional)
(shape optional)
Outfall and Spoil-grounds
Areas used for Naval, Military or Air Force practice purposes
Buoys
Lights
(shape optional)
Differing from neighboring lights.
(shape optional)
Northern quadrant
Eastern quadrant
C37

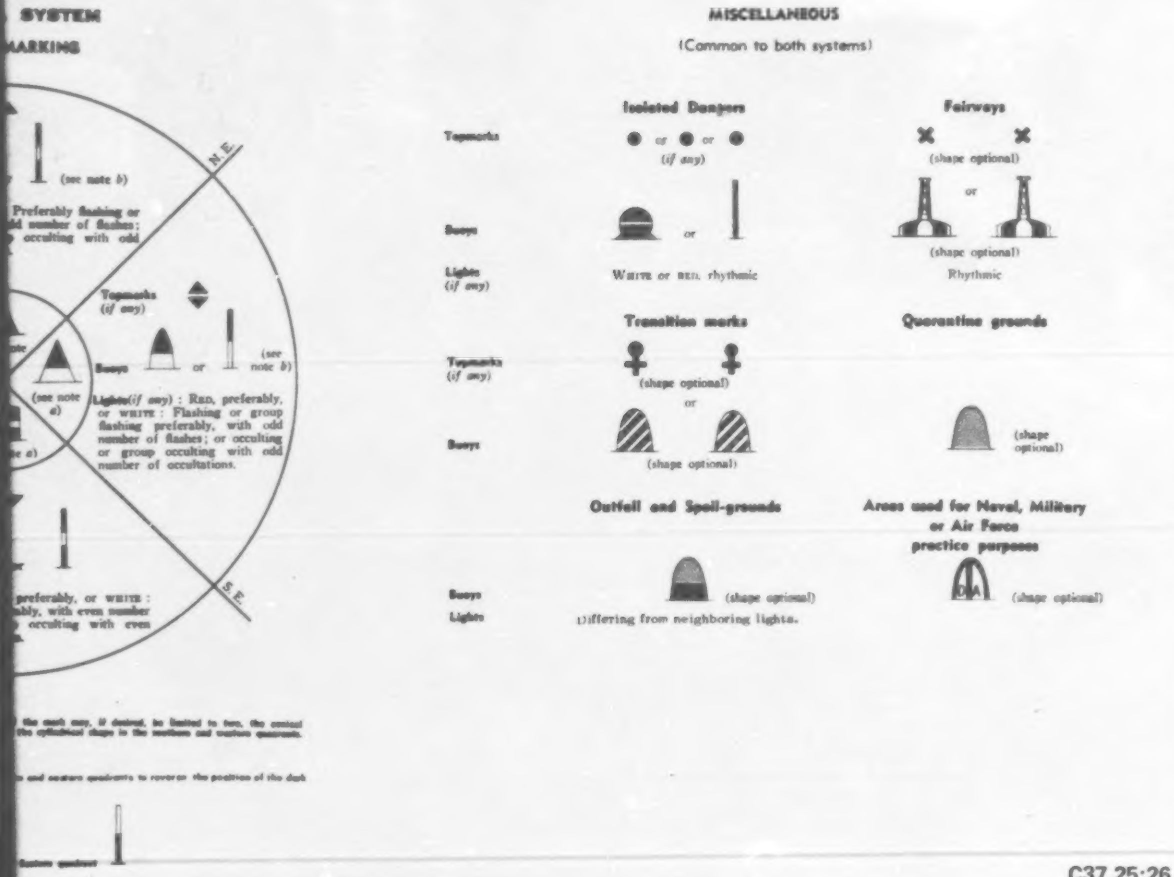
Note (a)

The number of characteristic shapes employed for the body of the mark may, if desired, be limited to two, the conical shape being employed in the northern and eastern quadrants, and the cylindrical shape in the southern and western quadrants.

Note (b)

When spars only are used, it may be advantageous in the northern and eastern quadrants to reverse the position of the dark colors; in this case the colors will be:

Figure 5-7.—Cardinal buoyage system.


SYSTEM
MARKING
(see note b)
Preferably flashing or
dd number of flashes;
occulting with odd
N.E.
Topmarks (if any)
Buoys
or
(see note b)
(see note a)
(see note a)
Lights (if any) : Red, preferably, or white : Flashing or group flashing preferably, with odd number of flashes; or occulting or group occulting with odd number of occultations.
S.E.
preferably, or white :
ably, with even number
occulting with even
the mark may, if desired, be limited to two, the conical
the cylindrical shape in the southern and western quadrants.
and eastern quadrants to reverse the position of the dark
Eastern quadrant
MISCELLANEOUS
(Common to both systems)
Isolated Dangers
Fairways
Topmarks
or
or
(if any)
(shape optional)
or
Buoys
or
(shape optional)
Lights (if any)
White or red rhythmic
Rhythmic
Transition marks
Quarantine grounds
Topmarks (if any)
(shape optional)
or
Buoys
(shape optional)
(shape optional)
Outfall and Spoil-grounds
Areas used for Naval, Military or Air Force practice purposes
Buoys
(shape optional)
(shape optional)
Lights
Differing from neighboring lights.

C37.25:26

Figure 5-7.—Cardinal buoyage system.

CHAPTER 6

RULES OF THE ROAD

You already are acquainted with basic rules of the road through study of the *Seaman* training manual. A quartermaster of the watch must have a broader knowledge of the rules of the road; he should know them at least to the extent covered in this chapter. All the rules can be found in Rules of the Road, CG-169. Material on rules of the road contained in this course is arranged to make the rules easy to remember. In most instances, instead of the exact wording, only the sense of each rule is given.

APPLICABLE RULES

International Regulations for Preventing Collisions at Sea dated 1960 (commonly called International Rules of the Road) has been adopted by most of the maritime nations of the world. This version incorporates changes, amendments, and new provisions necessitated by deficiencies in the previous regulations and by the great increase in shipping. The present rules of the road were enacted by Congress in 1963, proclaimed by the President in 1964, and put into effect 1 September 1965.

In October of 1972 a conference was held under the auspices of the Inter-Governmental Maritime Consultative Organization to revise and update the International Rules of the Road. The outcome of that conference—the Convention on the International Regulations for Preventing Collisions at Sea, 1972, including the Rules and Annexes attached thereto (1972 Regulations)—was a major revision of the 1960 International Regulations for Preventing Collisions at Sea. The U.S. was an active participant in the conference and, subject to ratification, accepted the convention as finally adopted. Once these rules have been ratified by enough countries they will enter into force one year later.

All of the International Rules discussed in this chapter are from the 1960 International Regulations for Preventing Collisions at Sea.

By act of Congress in 1897, the United States adopted the system of United States Inland Rules of the Road, which apply in "all harbors, rivers, and inland waters of the United States, except the Great Lakes and their connecting and tributary waters as far east as Montreal, Canada, and the Red River of the North and rivers emptying into the Gulf of Mexico."

Certain additional rules, known as Pilot Rules, are drawn up by the Commandant of the Coast Guard, with approval by the Secretary of Transportation. The Pilot Rules are in three parts. The first, (part 80) contains rules that apply in the same waters as Inland Rules. Most of the boundaries between international and United States inland waters are set forth in CG-169. The same information is contained in Coast Pilot, a National Oceanic Survey publication, which also includes the boundaries between inland waters and the high seas in Hawaii and Alaska.

Following is the general rule, as stated in CG-169, for establishing boundaries between international and United States inland waters in localities where no specific boundary line is prescribed:

> "At all buoyed entrances from seaward to bays, sounds, rivers, or other estuaries for which specific lines are not prescribed herein, Inland Rules of the Road shall apply inshore of a line approximately parallel with

the general trend of the shore, drawn through the outermost buoy or other aid to navigation of any system of aids."

Part 80 of the Pilot Rules, then, contains rules that supplement the Inland Rules and apply in the same waters. Incidentally, the Pilot Rules cannot contradict the Inland Rules. Where the rules conflict, the Inland Rules take precedence.

A Quartermaster must know the boundaries between international and inland waters. When a ship crosses this boundary, an entry to this effect is made in the ship's log, and significant changes in the rules occur at that instant.

Part 90 of the Pilot Rules contains rules for the Great Lakes and their connecting and tributary waters. Part 95 contains rules for the Red River of the North and the rivers flowing into the Gulf of Mexico. Many of the Pilot Rules that apply in inland waters are most important, particularly the one governing a whistle signal for a crossing situation (discussed later).

Some foreign governments have local rules that may be found in Sailing Directions. More generally, however, local rules for foreign waters must be obtained from local authorities. In foreign jurisdictions that have no local rules, International Rules usually are observed.

Where differences are significant in the International, Inland, and Pilot Rules covered in this chapter, these differences are pointed out so that you may know which rule applies where and when. In instances where all three rules are essentially the same, only one definition is given and it is referred to simply as "the Rule."

As defined in the Rules of the Road, a power-driven or steam vessel means any vessel propelled by machinery, even though she may also be under sail. Any vessel under sail alone is considered a sailing vessel whether machinery is aboard or not. A vessel is underway when she is not at anchor, aground, or made fast to the shore. She doesn't have to be actually making headway.

RULES FOR LIGHTS

Rules for lights must be complied with in all weathers, from sunset to sunrise, as specified by both International and Inland Rules of the Road. Ships usually show no outside lights at night during wartime conditions, of course, but even then lights are kept ready for emergency display. The Pilot Rules prohibit flashing the rays of a searchlight or other blinding light onto the bridge or into the pilothouse of a vessel underway. Commonsense dictates that this rule must be observed in all waters. The Pilot Rules also forbid showing any lights that may either obstruct or be mistaken for the prescribed lights.

MASTHEAD AND RANGE LIGHTS

International Rules differ somewhat from the Inland Rules governing masthead lights and range lights prescribed for power-driven vessels. The variations are discussed in the next two topics.

International Rules

A power-driven vessel underway carries at the masthead, or at some other elevated point forward, a bright 20-point white light visible from dead ahead to 2-points abaft the beam. (A point is 11 1/4° of the compass.) The light must be displayed between 20 and 40 feet above the deck. The masthead light must be visible for at least 5 miles. When the rules say "visible," they mean "visible on a dark night with a clear atmosphere."

In addition to the masthead light, a power-driven vessel over 150 feet in length must carry another 20-point white light aft, and it must be at least 15 feet higher than the masthead light. The after light is called the range light. Its use is mandatory except for vessels less than 150 feet in length.

Inland Rules

A power-driven vessel operating only in inland waters carries a 20-point masthead light forward, as under International Rules. Her range light is a 32-point (360°) light. If a seagoing vessel carries a range light in accordance with International Rules, she need not alter her 20-point range light when entering inland waters. In both international and inland waters, the horizontal distance between the lights must be more than the vertical distance.

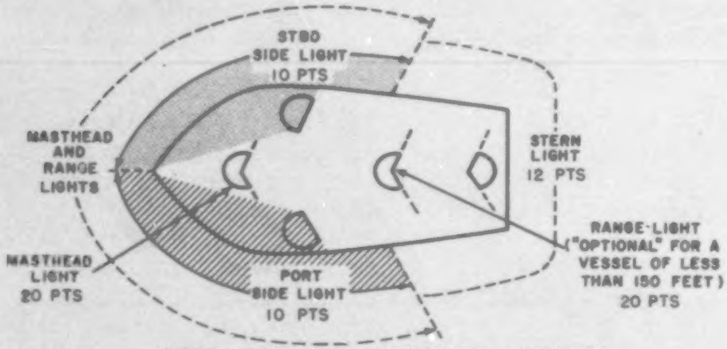
SIDE AND STERN LIGHTS

Every ship carries a 10-point green light on the starboard side and a 10-point red light on the port side. Each light must be visible for 2 miles dead ahead to 2 points abaft the beam on the appropriate side. Each side light must be fitted with a screen projecting at least 3 feet forward from the light so as to prevent its being seen across the bow.

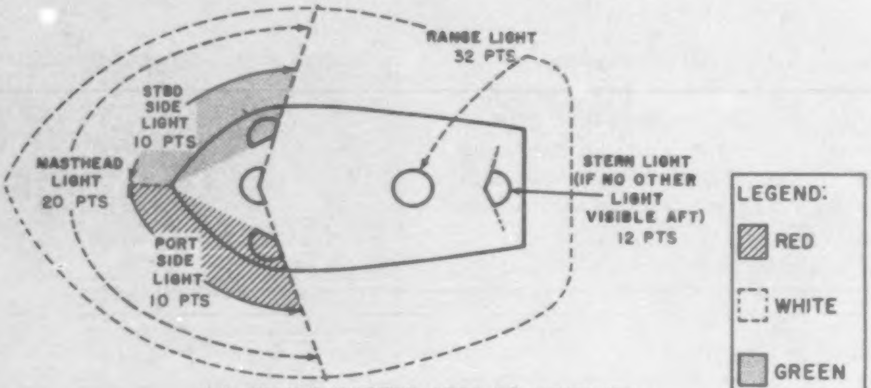
A ship underway also must display a 12-point white stern light (figure 6-1). It must be visible for 2 miles and under Inland Rules should be carried as nearly as possible on the same level as the side lights. On a small ship, when it is impossible to have a fixed stern light, a lantern or flareup light is kept ready and is shown at the approach of an overtaking ship. A stern light is not required in inland waters if the ship displays any other bright light visible from aft. Thus, if an all-around range light is shown, a stern light need not be shown in inland waters.

RUNNING LIGHTS ON POWERBOATS

Under International Rules, a power-driven boat under 65 feet in length (which represents


STBD SIDE LIGHT 10 PTS
MASTHEAD AND RANGE LIGHTS
STERN LIGHT 12 PTS
RANGE LIGHT ("OPTIONAL" FOR A VESSEL OF LESS THAN 150 FEET) 20 PTS
MASTHEAD LIGHT 20 PTS
PORT SIDE LIGHT 10 PTS

INTERNATIONAL RULES—ARCS OF VISIBILITY (AND U.S. INLAND WATERS—SEAGOING VESSEL)


RANGE LIGHT 32 PTS
STBD SIDE LIGHT 10 PTS
MASTHEAD LIGHT 20 PTS
STERN LIGHT (IF NO OTHER LIGHT VISIBLE AFT) 12 PTS
PORT SIDE LIGHT 10 PTS
LEGEND:
▨ RED
☐ WHITE
▒ GREEN

U.S. INLAND WATERS—ARCS OF VISIBILITY (NON-SEAGOING VESSEL)

69.27

Figure 6-1.—Running lights.

most boats carried on seagoing ships) carries a 20-point light forward, at least 9 feet above the gunwale and visible for a least 3 miles. She may carry either separate green and red side lights or a combined lantern showing green on the starboard side and red on the port side. The combined lantern must be so fixed as to show from dead ahead to 2 points abaft the beam on the appropriate sides. The side lights or combined lantern must be at least 3 feet below the white light and must be visible at least 1 mile.

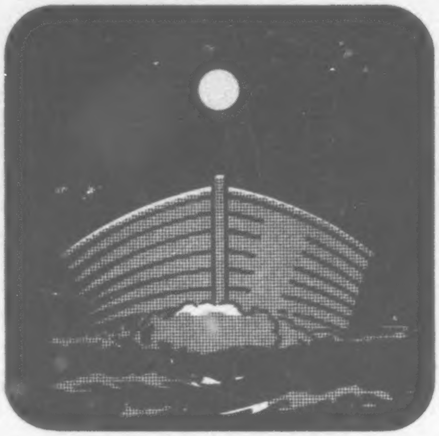
Under Inland Rules, running light for powerboats in United States waters are prescribed in the Motorboat Act of 1940. The Motorboat Act expressly provides, however, that boats equipped with lights in accordance with the International Rules may carry and exhibit those lights in lieu of the lights prescribed in the Motorboat Act. The act divides powerboats into the following classes:

Class A:	Less than 16 feet in length.
Class 1:	16 feet or over, but less than 26 feet.
Class 2:	26 feet or over, but less than 40 feet.
Class 3:	40 feet or over, but not more than 65 feet.

Each class A and class 1 boat carries an all-around white light aft and a combined lantern forward. The combined lantern is fixed to show its red and green lights in the same manner as the combined lantern in international waters, and it must be lower than the after white light. (See figure 6-2.)

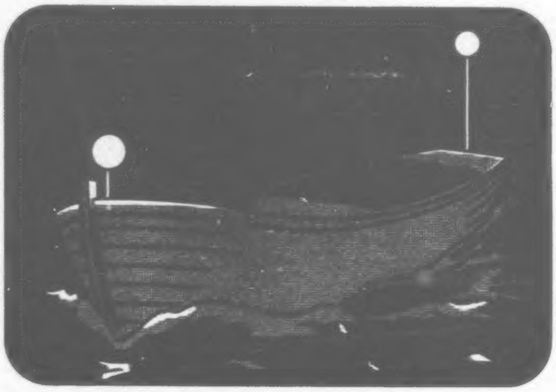
Classes 2 and 3 include most of the powerboats used in the Navy. Distinctions between boats of class 2 and class 3 set forth in the Motorboat Act are concerned with matters not related to running lights. Each in these classes shows a 20-point white light forward and an all-around light aft. The after light must be higher than the forward light. (See figure 6-3.) Normally the after light on motor launches and motor whaleboats is on the flagstaff. Each class 2 and class 3 powerboat must have separate red and green side lights (instead of the combined lantern) showing from dead ahead to 2 points abaft the beam.

When a motorboat is under sail, she carries her normal side lights and must have ready at hand a lantern or flashlight, showing a white light, which shall be exhibited in ample time to avert collision.



C 17.25.1

Figure 6-2.—The combination light on powerboats must be lower than the white after light.



C17.25.2

Figure 6-3.—Position of white lights on motorboats.

The white lights used by motorboats must be visible for at least 2 miles. Colored lights must be visible 1 mile.

LIGHTS ON PILOT VESSELS

An OOD or conning officer is anxious to sight the pilot boat and signal her alongside without being forced to lie to when conditions may be setting the ship toward a lee shore. Quartermasters must be able to recognize a pilot vessel the instant she is sighted. "White over red, pilot ahead" is the memory aid for the Quartermaster to recall when sighting a power-driven pilot vessel.

When a pilot vessel is not engaged on station, whether under International or Inland Rules, she is required to carry the same lights as other vessels of her length.

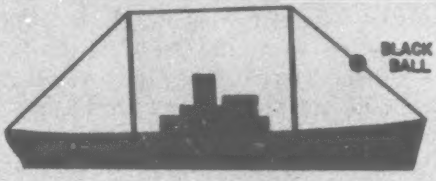
Under International Rules, a sailing pilot vessel, when engaged on her station and not at anchor, carries an all-around white light from the masthead, visible to a distance of at least 3 miles. She also exhibits a flareup light at intervals not exceeding 10 minutes. Additionally, she displays colored side lights, which need not be shown continuously, but must be flashed upon the approach of another vessel.

A power-driven pilot vessel, when on station and not at anchor, carries the lights prescribed for sailing pilot vessels. She also carries an all-around red light, visible for 3 miles, 8 feet below her white masthead light. She is required to display colored side lights when underway. In place of the flareup light, she may carry a bright, intermittent white light.

The Inland Rules that apply to lights on a pilot vessel are much the same as International Rules. The differences are that the red light must be visible at a distance of 2 miles, and the flare interval is not to exceed 15 minutes.

LIGHTS ON VESSELS AT ANCHOR

Under both International and Inland Rules, a ship less than 150 feet in length at anchor shows an all-around white light forward. This light is called the forward anchor light. It must be visible for at least 2 miles. Usually the forward anchor light is hoisted to a block on the forestay or to the jackstaff.



17.28.2

Figure 6-4.—Anchor signal.

Under both rules, a vessel 150 feet long or over carries her forward anchor light at least 20 feet above the hull. A similar light is carried aft, not less than 15 feet lower than the forward light. Both lights must be visible all around the horizon for a distance of at least 3 miles.

Remember that the range light must be 15 feet higher than the masthead light, but the after anchor light is 15 feet lower than the forward one. When the anchor lights come on, all running lights must be turned off.

International Rules provide that every vessel at anchor must display, between sunrise and sunset, a black ball a minimum of 2 feet in diameter. (See figure 6-4.) It is shown on the forward part of the vessel where it can best be seen.

According to Pilot Rules, every vessel greater than 65 feet in length, moored or anchored in a fairway or channel, must display the black ball prescribed under International Rules.

LIGHTS ON TOWING VESSELS

Both rules state that a towing vessel may carry, in lieu of the sternlight, a small white light abaft the funnel or aftermast for the vessel towed to steer by, but such light must not be visible forward of the beam.

International Rules

A power-driven vessel either towing or pushing another vessel must display two masthead lights in a vertical line not less than 6 feet apart. If she is towing and the length of the tow measured from the stern of the towing vessel to the stern of the last vessel towed exceeds 600 feet, she carries a third light at least 6 feet above or below the other two lights. Consequently, when you see three masthead lights in international waters, you are looking at a ship towing astern, with her tows ranging more than 600 feet.

Inland Rules

Towing lights on an inland vessel may be either forward or aft. If forward, they are 20-point lights like the masthead light. If aft, they are 32-point lights like the range light. The towing lights are 3 feet apart vertically.

Two white towing lights on an inland vessel, either forward or aft, signify that the tow is secured alongside the towing vessel or is being pushed. If the vessel is carrying her towing lights forward and is pushing one or more vessels, she also carries, at or near her stern, two amber lights in a vertical line not less than 3 feet apart. They must be 12-point lights showing from right aft to 6 points on either side and visible for 2 miles. When towing astern, regardless of the length of the tow, the towing vessel shows three white lights.

NOT-UNDER-COMMAND LIGHTS

The term "not under command" as used in the International Rules of the Road refers to ships and craft which are physically disabled and are therefore unable to maneuver in accordance with the rules. Rule 4 says a ship not under command at night must show two red lights, one over the other and not less than 6 feet apart, where they may best be seen. They must be visible all around the horizon at a distance of at least 2 miles. During daylight she hoists two black balls or shapes at least 6 feet apart. If she is a power-driven vessel, she shows the not-under-command lights in lieu of her masthead light. If she is making no headway, she shows the red lights only; if making headway, she shows her side lights and stern light as well. The reason for this procedure is obvious. If a ship is not under command, it is urgent that nearby ships know whether she is making headway and, if so, the direction she is headed.

The Inland Rules contain no provision for not-under-command lights comparable to rule 4 of the International Rules. A ship not under command in inland waters shows only her regular running lights at night and no prescribed signal by daylight. You already know that a naval vessel breaks the 5 flag when she is not under command in daylight. But, in international waters, she also hoists two black balls as a warning to any merchant vessels in the vicinity.

OTHER LIGHTS AND DISPLAYS

The Rules of the Road go into extensive detail concerning special lights and displays that must be shown by vessels engaged in operations restricting their ability to maneuver. This section describes these special lights and displays.

Fishing Vessels

In international waters, a fishing vessel not engaged in fishing shows the same lights or shapes as other vessels of similar length. In

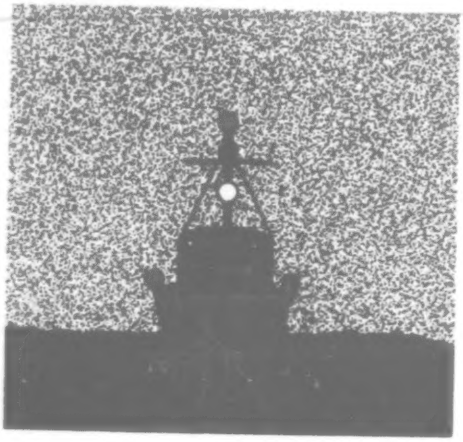


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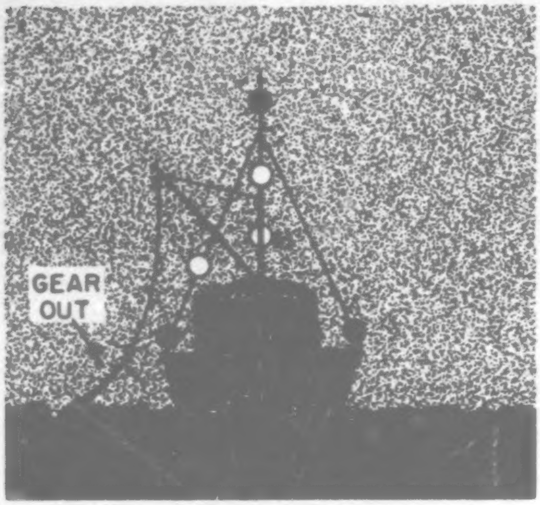
Figure 6-5.—Fishing vessel engaged in trawling—International Rules.



C112.51

Figure 6-6.—Fishing vessels with nets extended greater than 500 feet—International Rules.

inland waters, a fishing vessel underway but not engaged in fishing and under 10 tons gross weight is not required to show side lights. Instead, she may have a green and a red lantern ready to show on the appropriate side when in the vicinity of other ships. If the vessel is of 10 gross tons or more, however, she must show the same lights as other vessels.

The lights prescribed for fishing vessels in international waters must be visible at a distance of at least 2 miles, unless otherwise indicated.

A vessel engaged in trawling carries two lights in a vertical line, one over the other, 4 to 12 feet apart. The upper light is an all-around green light; the lower light is an all-around white light. (See figure 6-5.) This vessel may also carry a white 20-point light abaft the all-around lights visible at a distance of 5 miles. Such a vessel carries colored side lights and a stern light only when she is making way.

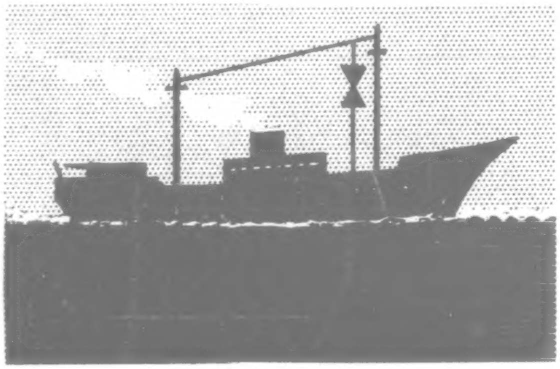
A vessel engaged in fishing with nets or lines extending not more than 500 feet (except a vessel engaged in trawling) shows the same all-around lights as for trawling, except that the upper light is red. When making way, this vessel displays side lights and a stern light.

A fishing vessel (except a vessel engaged in trawling) with nets or lines extending greater than 500 feet horizontally carries, in addition to the lights mentioned in the previous paragraph, an all-around white light in the direction of the outlying gear. (See figure 6-6.)

By day a fishing vessel indicates her occupation by displaying a black shape consisting of two cones with their points together, one over the other (figure 6-7). If the vessel is less than 65 feet in length, a basket may be substituted for the black shape.

Under Inland Rules, a fishing vessel, when fishing with any kind of dragnets or lines, must exhibit two lights, one red and one white. The red light is displayed 6 to 12 feet over the white light. The horizontal distance between the two should be no more than 10 feet. (A memory aid for lights on a fishing vessel is: "Red over white, fishing at night.") Both lights are all-around lights. The red light must be visible for a distance not less than 2 miles. The white light must be visible for at least 3 miles. (See figure 6-8.)

During the day, a fishing vessel indicates her occupation to approaching vessels by displaying a basket where it can best be seen. If an anchored fishing vessel has its gear out, it must display the basket in the direction from the anchor toward the gear.



112.52

Figure 6-7.—Day shape, fishing vessel—International Rules.

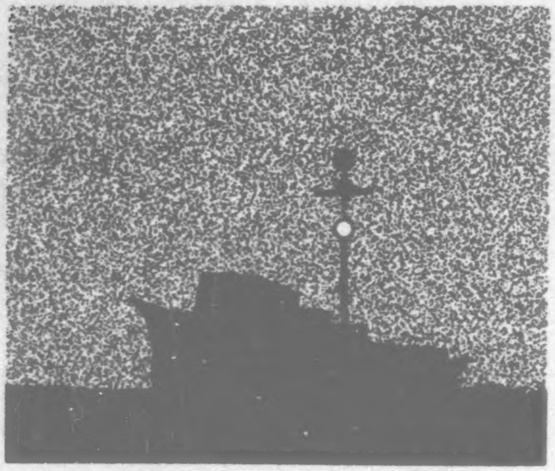


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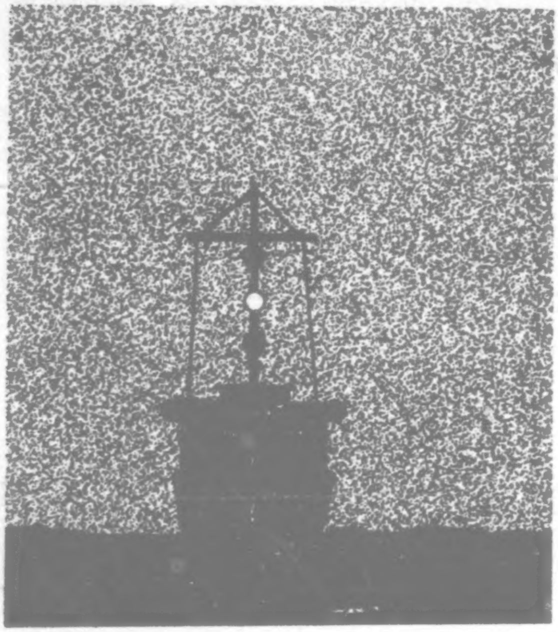
Figure 6-8.—Fishing vessel—Inland Rules.



C112.55
Figure 6-9.—Vessel engaged in underwater operations—International Rules.

Vessels Engaged in Restricted Operations

In this section, the term "restricted operations" refers to laying or picking up submarine cable or navigation aids, surveying, replenishing at sea, launching and recovering aircraft, or any other operations which restrict a vessel's ability to maneuver.

When a vessel engaged in restricted operations is unable, because of the nature of her work, to get out of the way of approaching vessels, International Rules require her to display three vertical all-around lights not less than 6 feet apart. All three lights must be visible for at least 2 miles. The top and bottom lights are red and the middle light is white. Figure 6-9 shows these lights and the side lights that also must be displayed. During daytime, this vessel carries three shapes. The highest and lowest are red global shapes; the middle shape is a white diamond. (See figure 6-10.) The shapes are not less than 6 feet apart, and are 2 feet in diameter.

Inland Pilot Rules differ from International Rules in that they require different lights and shapes for various operations included in the general term "restricted operations."

A vessel towing a submerged object at night is required to show four lights, arranged

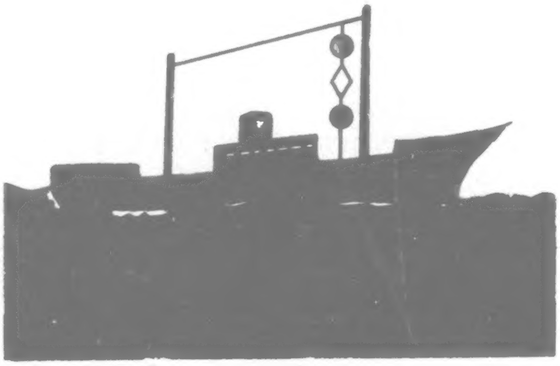


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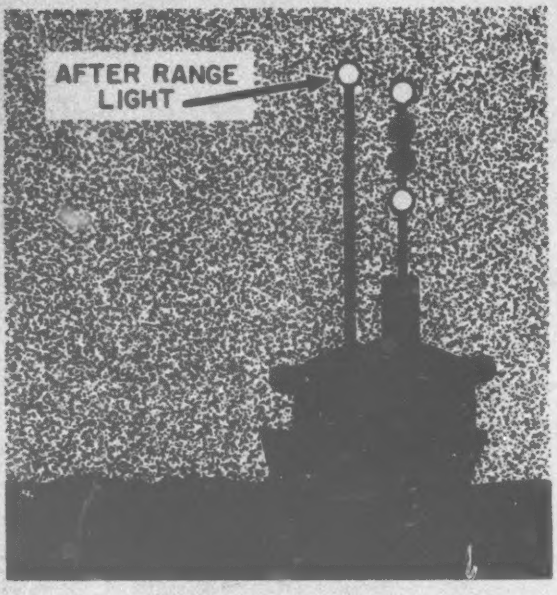
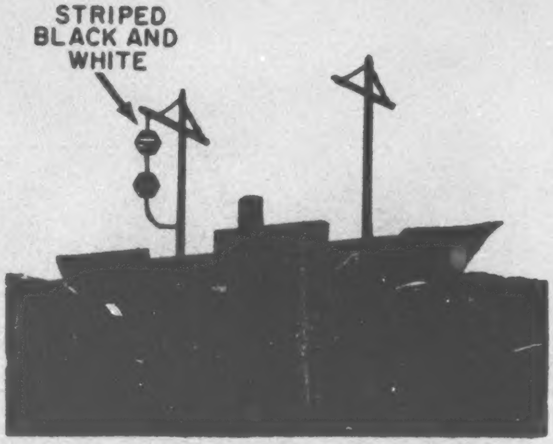
Figure 6-10.—Day shapes, underwater operations—International Rules.



C112.57
Figure 6-11.—Vessel with submerged tow—Inland Rules.

vertically 3 to 6 feet apart. The upper and lower lights are white; the two middle lights are red. All four lights must be visible for a distance of at least 2 miles. This vessel also carries side lights and an after range light. (See figure 6-11.) During the day, she must display two shapes, one above the other, not less than 6 feet apart. The lower shape is at least 10 feet above the deckhouse. The shapes are in the form of a double frustum of a cone, not less than 8 inches at the end. They should be 4 feet in length. The upper shape is painted in alternate horizontal black and white stripes, and the lower shape is red. (See figure 6-12.)

A vessel made fast alongside a wreck, or moored over a wreck that is on the bottom or partly submerged, displays white lights from the bow and the stern, not less than 6 feet above the deck. Additionally, this vessel must show two vertically arranged red lights, 3 to 6 feet apart and not less than 15 feet above the deck (figure 6-13). The day shapes are of the same character and dimensions as those for a vessel towing submerged objects, except that both shapes are painted red.



C112.58
Figure 6-12.—Day shapes, vessel with submerged tow—Inland Rules.

A dredge held in position by moorings or spuds displays a white light at each corner at least 6 feet above the deck. She also shows two red lights in a vertical line 3 to 6 feet apart, not less than 15 feet above the deck. (See figure 6-14.) During the day, two red balls are displayed in a vertical line 3 to 6 feet apart and at least 15 feet above the deckhouse in a

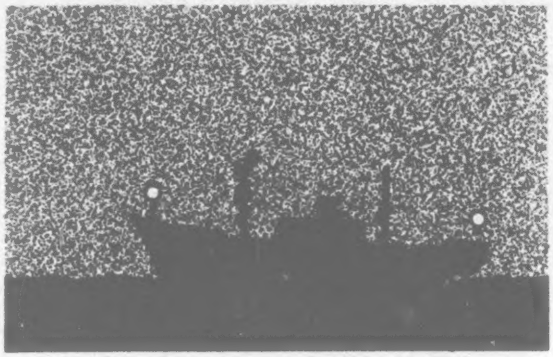


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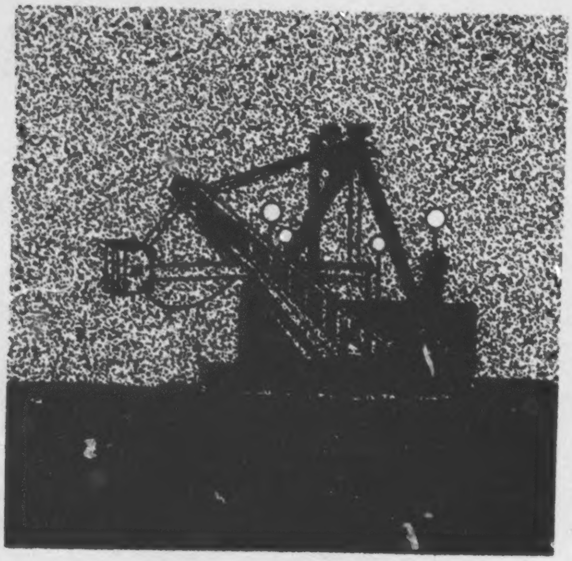
Figure 6-13.—Vessel made fast over a wreck—Inland Rules.



C112.60

Figure 6-14.—Dredge held stationary—Inland Rules.

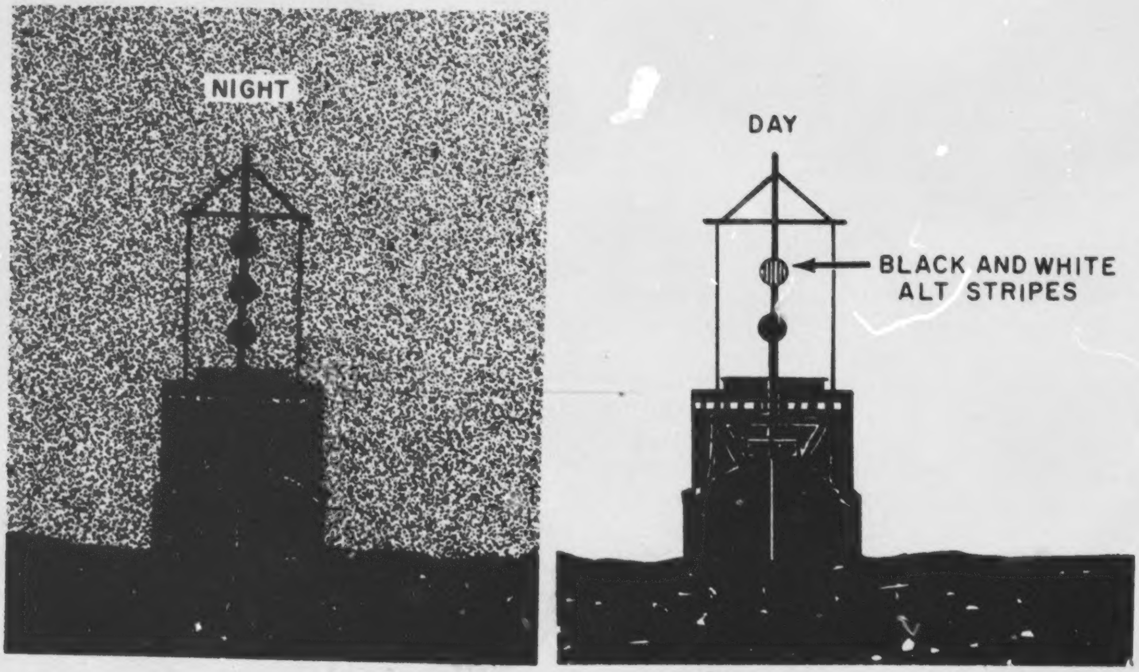
position where they can best be seen from all directions.

At night, a vessel moored or anchored and engaged in laying cables or pipe, submarine construction, excavation, mat sinking, bank grading, or other bank protection operations displays three red lights in a vertical line, 3 to 6 feet apart. The lowest light must be at least 15 feet above the deck. (See figure 6-15.)

During the day, this vessel shows two balls in a vertical line at least 15 feet above the deck. The upper ball is painted in alternate black and white stripes, and the lower ball is painted red.

Vessels Aground

International Rules require that a vessel under 150 feet in length, when she goes aground, carry on the bow of the ship, where it can best be seen, a white light that is visible for at least 2 miles. She must also carry, in a vertical line and 3 to 6 feet apart, two all-around red lights which are visible for at least 2 miles.



C112.61

Figure 6-15.—Vessel laying cable—Inland Rules.

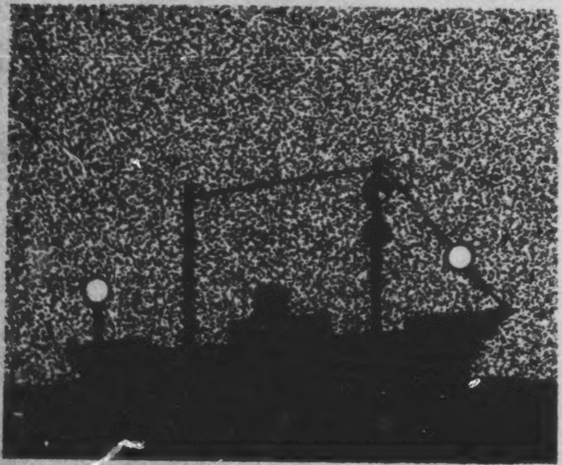
A vessel 150 feet or over must display a white light in the forepart of the vessel, at least 20 feet above the hull, and a white light near the stern of the vessel, not less than 15 feet lower than the forward light. (This light is optional on a vessel less than 150 feet in length.) The two red lights specified for a vessel under 150 feet are also required. (See figure 6-16.)

By day, a vessel aground shows three black balls in a vertical line not less than 6 feet apart.

Inland Rules do not provide for a vessel that goes aground. Courts have ruled, however, that a vessel aground in inland waters should display anchor signals. This decision means that during the night such a vessel should display the same lights as required by International Rules (with the exception of the red vertical lights). During the day, such a vessel displays a single black ball where it can best be seen by other vessels.

Sailing Vessels

Both International and Inland Rules provide that a sailing vessel underway must carry red and green side lights and must display a white stern light. In International Rules she may also carry on the top foremast a red light over a green light.



C112.62

Figure 6-16.—Vessel aground, over 150 feet—International Rules.

Vessels in Tow and Ferryboats

This topic describes lights and shapes for barges and canalboats in tow in international and inland waters. Lights and shapes for ferryboats are described for Inland Rules only. International Rules do not provide for ferryboats.

Under International Rules any vessel being towed carries side lights. She carries, in addition, a white stern light visible over an arc of 135° (67 1/2° on either side of the stern).

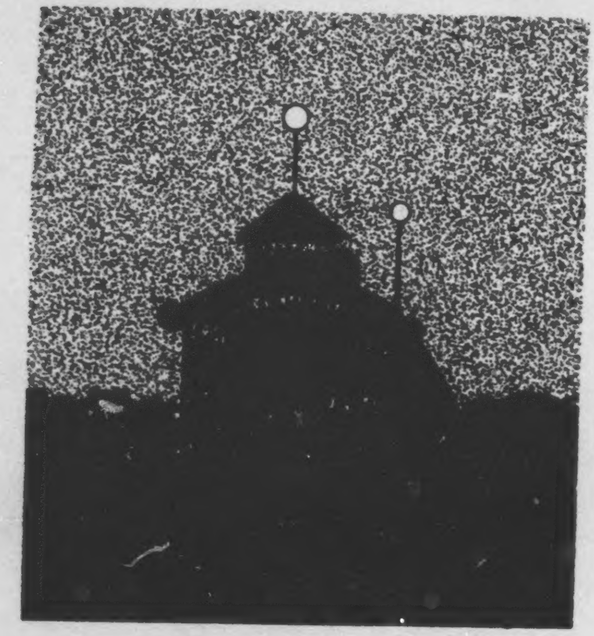
The following Inland Rules apply to ferryboats and to barges and canalboats on both the Atlantic and Pacific coasts.

FERRYBOATS.–Power-driven ferryboats navigating in inland waters, except those waters covered in Pilot Rules for the Western Rivers and in Pilot Rules for the Great Lakes and Their Connecting and Tributary Waters, carry the range and side lights required by law for steam vessels navigating in those waters. The only exception is the double-end ferryboat, which is required to carry a central range of white lights showing all around the horizon and placed at equal altitudes fore and aft. Figure 6-17 shows a double-end ferryboat.

BARGES AND CANALBOATS–ATLANTIC AND PACIFIC COASTS.–Each barge, canalboat, and other nondescript vessel when towed astern of a steam vessel–as in tandem towing (figure 6-18)–carries a green light on the starboard side and a red light on the port side. Each vessel also carries a white stern light, except the last vessel of the tow which carries two white lights.

When two or more barges, canalboats, or other nondescript vessels are towed abreast, side lights are carried at the outer sides of the bows of the vessels (figure 6-19). Each of the outside vessels in the last tier of a hawser tow must carry a white light on the stern.

A barge or a scow that is towed alongside a steam vessel must, if the deck, deckhouse, or cargo of the towed vessel obscures the side lights of the steam vessel, carry the proper side light on the tow to replace the hidden side light of the towing vessel.



C112.63

Figure 6-17.—Double-end ferry.

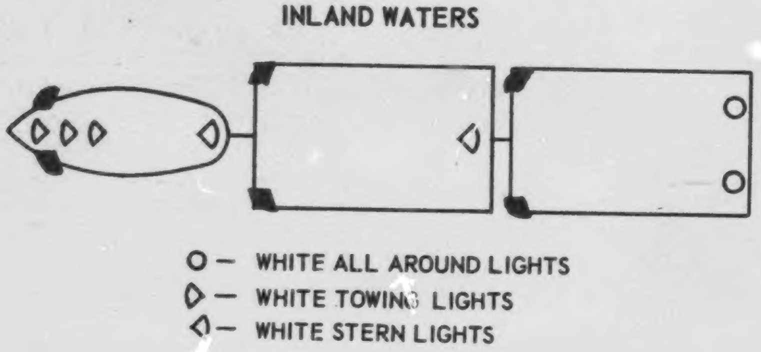
When a barge or canalboat is pushed ahead by the steam vessel, side lights are placed on the bow. If more than one vessel is pushed ahead, the side lights are placed on the lead vessel.

The same lights for barges and canalboats are applicable on most inland waters along the Atlantic and Pacific coasts. The lights required in some harbors and waterways are subject to changes and variations. To find these changes and variations, as well as the lights for barges and canalboats in other inland waters, refer to CG-169.

SPECIAL RULES FOR NAVAL VESSELS

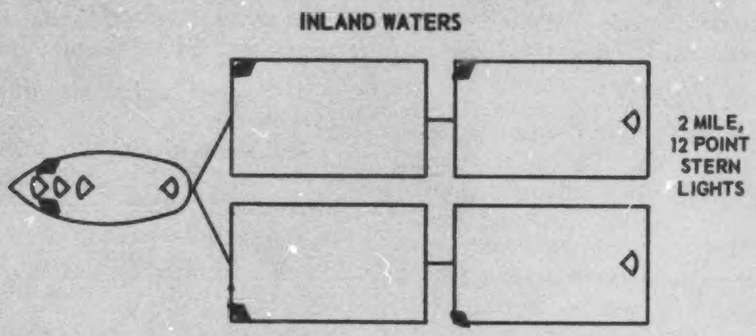
Many naval vessels, because of their special construction, are unable to comply strictly with the rules for running lights. For example: the horizontal separation of the white lights on destroyers and smaller ships is frequently less than that specified in the rules; and the white lights on aircraft carriers are usually on the superstructure and, thus, considerably off the centerline. The lights on such specially constructed vessels must, nevertheless, meet the requirements of the rules as nearly as possible.

Naval vessels may also be expected to show certain other lights not mentioned in the rules (such as speed lights, carrier landing lights, and



C80.121

Figure 6-18.—A tow in tandem.



C80.121

Figure 6-19.—Canalboats and barges abreast in tiers.

colored recognition lights); or during darken ship exercises, they may show no lights at all. These departures from the Rules of the Road are provided for by U.S. laws and statutes.

Minesweepers

Minesweepers, when not sweeping, display the same lights and signals as other vessels of equivalent length. In international and inland waters, a minesweeper engaged in sweeping (figure 6-20) displays the following lights:

1. A green all-around light is shown from the fore masthead before passing or streaming sweeps.
2. A green all-around light is hoisted at the yardarm on the side(s) on which it is dangerous for other vessels to pass.
3. The required running lights for a ship of her class are also carried.

During the day, minesweepers substitute black balls (figure 6-21) for the green lights they display at night. Minesweepers may also use some special signals during the day.

C112.64

Figure 6-20.—Minesweeper engaged in sweeping at night, sweeps streamed on both sides.

Submarines

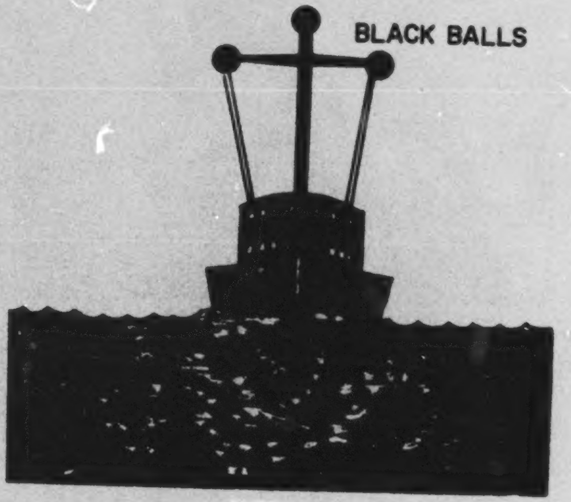
In accordance with International Rules and Inland Rules, the Secretary of the Navy has authorized the display of a distinctive light by each U.S. Navy submarine in international waters and in the inland waters of the United States. The light must be exhibited in addition to the presently prescribed navigational lights for submarines because the normal navigational lights have been found to be easily mistaken for those of small vessels when in fact submarines are large deep-draft vessels with limited maneuvering characteristics while they are on the surface.

Thus, the light is expected to promote safety at sea by assisting in the identification of submarines. Each United States submarine must therefore display an amber rotating light producing 90 flashes per minute visible all around the horizon at a distance of at least 3 miles. The light is located not less than 2 feet, and not more than 6 feet above the masthead light.

SOUND SIGNALS FOR FOG

A power-driven vessel sounds her fog signals on the whistle or siren (Inland only); sailing vessels, on the foghorn; and vessels in tow, on the whistle or foghorn (Inland only). When a "prolonged blast" is mentioned in the rules, it means a blast of from 4 to 6 seconds duration. A short blast or blast is about 1 second.

A power-driven vessel underway in a fog (or thick weather of any kind) is required by International Rules to sound a prolonged blast at 2-minute intervals. Inland Rules require the same signal, but at 1-minute intervals.



112.65

Figure 6-21.—Minesweeper—day shape.

In inland waters, a power-driven vessel underway in fog sounds one prolonged blast whether she is making way or is stopped with no way on. Under International Rules, a power-driven vessel underway in a fog, but stopped and having no way on, sounds two prolonged blasts, with about 1 second between them, at intervals not exceeding 2 minutes.

Under both International and Inland Rules, a power-driven vessel towing another vessel sounds one prolonged blast and two short blasts at 1-minute intervals. This same signal is sounded in international waters by a vessel not under command in fog. In inland waters a vessel not under command or unable to maneuver in fog (except a power-driven vessel towing) cannot signal her plight and can do nothing but sound a prolonged blast at 1-minute intervals.

Under Inland Rules, one prolonged blast, followed by two short ones is the signal given by a vessel being towed in fog. International Rules specify that the last vessel of the tow must give one prolonged blast followed by three short ones. Under both rules the signals are sounded at 1-minute intervals.

A sailing vessel underway in fog sounds her foghorn at 1-minute intervals as follows:

1. On the starboard tack, one blast.
2. On the port tack, two blasts.
3. Wind abaft the beam, three blasts.

A vessel at anchor in fog (International and Inland) rings her bell rapidly for about 5 seconds at intervals of not more than 1 minute. By provisions of International Rules, a vessel over 350 feet in length rings a bell in the forward part of the vessel. In the after part, a gong, or some other instrument that cannot be confused with the bell, is sounded. The instrument is sounded for about 5 seconds at intervals of not more than 1 minute. If there is a possibility of collision, the vessel at anchor may sound three blasts (one short, one prolonged, and one short) to warn each approaching vessel of her position.

Table 6-1.–Summary of Fog Signals

International		Situation	Inland	
Signal	Maximum interval		Signal	Maximum interval
—	2 min.	Power-driven or steam vessel underway, with way on.	[illegible]	1 min.
— —	2 min.	Power-driven or steam vessel underway, but stopped, no way on.	—	1 min.
— ..	1 min.	Vessel not under command.	—	1 min.
X	1 min.	Vessel at anchor.	X	1 min.
3 X 3	1 min.	Vessel aground	X	1 min.
— ..	1 min.	Vessel towing	— . .	1 min.
— ...	1 min.	Vessel towed	— . .	1 min.
— ..	1 min.	Vessel laying submarine cable or navigation mark.	—	1 min.
— ..	1 min.	Vessel fishing	—	1 min.
		Sailing vessel:		
0	1 min.	On starboard tack.	0	1 min.
0 0	1 min.	On port tack	0 0	1 min.
0 0 0	1 min.	Wind abaft beam	0 0 0	1 min.

NOTES:

3 represents three strokes of bell.
X represents bell, forward, 5 seconds, vessels over 350 feet, when anchored in international water, sound gong aft also.
— represents a prolonged blast.
. represents a short blast.
0 represents a blast.

69.131

In addition to the signals sounded by a vessel at anchor, a vessel aground in international waters gives three separate and distinct strokes on the bell immediately before and after the anchored signal. Inland Rules for a ship aground are the same as those for an anchored ship.

If at any time a vessel hears a fog signal forward (or apparently forward) of her beam and cannot ascertain the position from which the signal is coming, she must stop her engines and navigate with caution until she is sure there is no danger of collision.

A stopwatch should be used by the man assigned the duty of sounding the fog signals. He should be directed to vary the intervals between signals frequently in case another vessel's signals are synchronized with his own, therefore each drowning out the other's signals. Table 6-1 will be helpful in learning fog signals.

STEERING AND SAILING RULES

Distinction must be made between Inland and International Rules whistle signals in several particulars; but first, note this general distinction between the two: international whistle signals are signals of execution; inland whistle signals are signals of intention.

Inasmuch as international waters are not as crowded as inland waters, it was not considered necessary to make whistle signals under the

International Rules as informative as those under Inland Rules. International whistle signals are sounded at the time the ship executes the manuever, and when in sight of another vessel.

The signals are as follows:

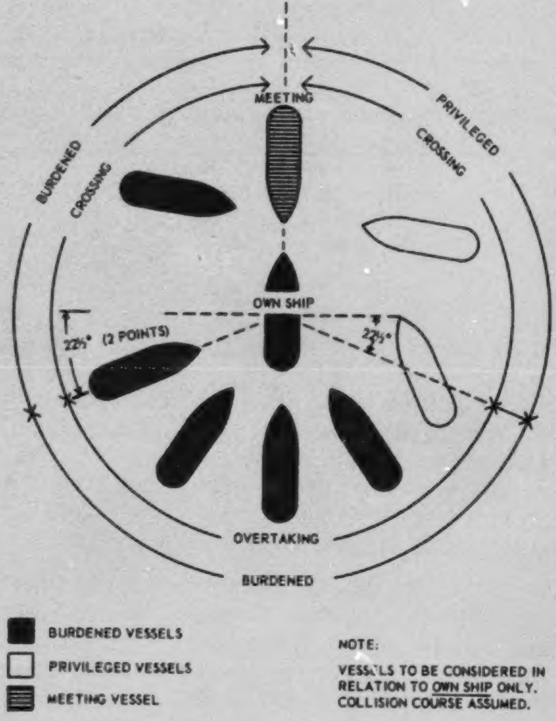
1. One short blast: I am altering my course to starboard.
2. Two short blasts: I am altering my course to port.
3. Three short blasts: My engines are going astern.

The close quarters and heavy traffic in inland waters make it necessary for Inland Rules whistle signals to be a better means of communication than international signals. Remember, however, that an inland signal is a signal of intention only. The ship that sounds the signal does not put her intention into execution until she receives an OK from the other vessel by the return of the same signal. If the other vessel does not understand the signal or considers the proposed maneuver of the first vessel dangerous, she replies with the danger signal—not less than four short, rapid blasts. (The doubt signal for international waters consists of at least five such blasts and may be sounded only by a privileged vessel.)

Confusion over whistle signals for meeting, crossing, and passing situations is probably responsible for more collisions than any other phase of the Rules of the Road. Read over this section on Steering and Sailing Rules until you clearly understand the distinction between international and inland whistle signals, and the application of the steering and sailing rules to various traffic situations. Although all the Rules of the Road are important, the steering and sailing rules are the ones most essential to know to avoid collision. Farwell's Rules of the Nautical Road is a valuable aid in interpreting the rules. Figure 6-22 illustrates several situations that might arise when two vessels approach each other. The illustration and the following summary should help you learn steering and sailing rules.

1. When two ships meet end-on, or nearly so, each ship must change course to starboard so as to pass port-to-port. In international waters, a whistle signal is sounded only when a course change actually is made. In inland waters, either vessel sounds the whistle signal, and it is to be answered with one by the other. If the meeting ships are already far enough off each other to pass clear on their present courses, no signal is sounded in international waters. In inland waters, either vessel must sound one short blast if intending to pass port-to-port; two short blasts, if intending to pass starboard-to-starboard. The signal must be answered by the other vessel.

2. When two steam vessels are crossing in international waters, the one having the other to starboard must keep clear by the best means available, but should cross ahead only when risk of collision does not exist or when in extremis. A whistle signal is sounded only when a course



58.86

Figure 6-22.—Meeting, crossing and overtaking situations.

change is made or the engines are backed. In inland waters, under the Pilot Rules, the privileged vessel must sound one blast to show her intention to maintain her course and speed. The burdened vessel must stand clear by passing under the stern of the privileged vessel. The terms "privileged vessel" and "burdened vessel" are further explained later.

3. A sailing vessel always has the right-of-way over a steam vessel, except when the sailing vessel is overtaking, or the steam vessel is a vessel engaged in fishing, or the vessels are navigating in a narrow channel in which the steam vessel must remain.

4. Any vessel overtaking another must keep clear. In international waters, a vessel passing another ship sounds a whistle signal only if she changes course. In inland waters, whether a change of course is made or not, an overtaking vessel must sound one short blast if she intends to pass to starboard; two, if she intends to pass to port. She must not pass until she hears a repeat of the same signal from the vessel being overtaken.

5. In inland waters the danger signal means either "I don't understand your intentions," or "I don't think what you intend to do is safe, and am about to signal for what I consider to be the safer procedure." In international waters the danger signal means "I am in doubt as to whether you are taking sufficient action to avoid collision."

WHO MUST KEEP CLEAR

The rules for lights are designed so that a ship's display at night will tell you as much as possible about her. Positioning the range light higher than the masthead light, for instance, frequently lets you know the direction a ship is heading before you can recognize her side lights. If the after anchor light is lower than the forward one, you are able to distinguish either end of an anchored ship.

The same rules apply to the sound signals for fog. You can tell from the sound whether the ship making the signal is anchored or underway. You know when she has a tow. In international waters, a certain signal tells you when a ship in fog is not under command.

In short, these sailing and steering rules are designed to help one ship keep clear of another. Now, the question arises: Which of two ships in sight of each other must haul off to let the other pass? The rules that govern in a situation like this are most important, and distinctions between International and Inland Rules are such that they must be very clear in your mind.

RISK OF COLLISION

Both International and Inland Rules talk about a situation in which two ships are approaching each other so as to involve risk of collision. Naturally, no maneuvering is required by ships that will pass clear by merely maintaining their present courses and speeds. But when the courses of two ships are converging so as to raise the possibility of a collision, one or the other must take some positive action, either by altering course, or by slowing, stopping, or backing her engines. The rules say:

> "Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist."

When the bearing of a vessel whose course is converging with yours remains constant, she is on a collision course. In such a situation, one vessel or the other is charged by the rules with keeping clear by the best means available.

The vessel keeping clear is referred to as the burdened vessel. The other vessel must maintain her course and speed until risk of collision no longer exists. She is said to have the right-of-way and is called the privileged vessel. The terms "burdened vessel" and "privileged vessel" must be applied in a strictly limited sense, however, because even the so-called privileged vessel is charged with definite responsibilities from which she may depart only in situations covered by the General Prudential Rule or the Rule of Good Seamanship.

General Prudential Rule

The General Prudential Rule (International and Inland Rule No. 27) makes it impossible for a privileged vessel to escape responsibility after standing into a recognized danger simply because her skipper was determined not to haul off when he had the right-of-way. International Rule No. 27 says:

> "In obeying and construing these Rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances, including the limitations of the craft involved, which may render a departure from the above Rules necessary in order to avoid immediate danger."

The corresponding Inland Rule 27 deletes the words "including the limitations of the craft involved."

Obviously, a vessel may depart from the requirements of the Rules of the Road, by provisions of the General Prudential Rule, only when an immediate danger exists which requires such a departure. When such a danger exists, it is termed "in extremis." Although we have mentioned the failure of a privileged vessel to heed the General Prudential Rule, in some conceivable situations a burdened vessel could be at fault in the same manner.

Rule of Good Seamanship

The Rule of Good Seamanship (Rule 29, Inland and International) reads as follows:

> "Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper look-out, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case."

The Rule of Good Seamanship is invoked in a situation where the immediate danger is not as pressing or as obvious as one justifying a departure from the letter of the rules under the General Prudential Rule. A good example is a tug, with a couple of tows streamed astern, coming down with a strong current from aft and crossing a single vessel on the tug's starboard bow. The literal interpretation of the rules says that the tug is the burdened vessel and must keep clear. Let's say the circumstances are such that, in order to do so, she must lie to. Any good seaman knows that if the tug does lie to, the tows will pile up on her stern. The Rule of Good Seamanship says she doesn't have to get herself in a situation like that just to let the other vessel have the right-of-way. Consequently, she can request permission to cross ahead, by appropriate whistle signal, as described later.

In considering the General Prudential Rule and the Rule of Good Seamanship, it must be borne in mind that a departure from the Rules of the Road is permissible only—positively only—when an immediate danger or special circumstance exists, or when the ordinary practice of seaman is required. Otherwise, the rules must be followed strictly. Naturally, only the OOD or conning officer of the vessel involved may decide when to apply the General Prudential Rule or the Rule of Good Seamanship.

MEETING END-ON

When two power-driven vessels meet end-on, or nearly end-on, so as to involve risk of collision, each must alter her course to starboard so they will pass each other port-to-port. Most of the rules describe a situation wherein one vessel or the other must keep clear, but this meeting end-on situation required both vessels to keep clear. The rule applies only when the ships are so nearly stem-to-stem as to see each other's masts in line in the daytime, or both of the other's side lights at night. If they are far enough off each other to pass clear without changing course, then each must maintain her present course and speed.

Each of the two ships so meeting, as already stated, must alter course to starboard so as to pass port-to-port. In inland waters, each ship sounds one short blast to indicate her intention to change course to starboard. In international waters, each ship sounds one blast when she changes course to starboard.

If the vessels are already far enough to port or starboard of each other to pass clear on their present courses, they must stay on their courses and pass clear. Here, an important distinction must be pointed out between International and Inland Rules. Because no course change is involved, no signal is made in international waters. Inland Rules require, however, that if the ships are to pass port-to-port, regardless of whether a course change is made, either ship sounds one short blast to signify her intention to pass port-to-port, and the other ship answers with one short blast to show it is OK with her. If they are going to pass starboard-to-starboard, whether or not a change of course is required, either ship sounds two short blasts, to be answered with two short blasts by the other.

CROSSING

In taking up crossing situations, we should recall the previously mentioned International and Inland Rule which says, in substance, that when a power-driven vessel and a sailing vessel are proceeding in such a direction as to involve risk of collision, the power-driven vessel must keep out of the way of the sailing vessel; but the sailing vessel does not have the right, in a narrow channel, to hamper the safe passage of a steam vessel that can navigate only inside the channel.

Rule 26 says that sailing vessels must keep out of the way of ships fishing with nets, lines, or trawls, but that fishing vessels may not obstruct channels with their gear.

From the foregoing, it is clear that, in any situation involving a power-driven vessel and a sailing vessel, the power-driven vessel must keep out of the way except when–

1. In a narrow channel and the sailing vessel can operate outside the channel but the power-driven vessel cannot.
2. The sailing vessel is overtaking the power-driven vessel.
3. A sailing vessel comes upon a power-driven fishing vessel. Rule 19, both Rules, says:

> "When two power-driven vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other."

In other words, the ship that has the other vessel to starboard is the burdened vessel; the ship that has the other one to port is the privileged vessel. A burdened vessel must keep out of the way by the best means available. The privileged vessel must maintain her present course and speed until the danger is past.

In a crossing situation in international waters, a whistle signal is made by either vessel only if she changes course or backs her engines. Inland Rules for whistle signals in a crossing situation are complicated by the following Pilot Rule:

> "One short blast of the whistle signifies intention to direct course to own starboard, except when two steam vessels are approaching each other at right angles or obliquely, when it signifies intention of steam vessel which is to starboard of the other to hold course and speed."

The privileged vessel in a crossing situation in inland waters, then, must sound a short blast to indicate she intends to maintain her course and speed.

The Pilot Rules state that two short blasts on the whistle mean an intention to direct own course to port. We already have seen that, under Inland Rules, two short blasts must be sounded in a meeting situation where two vessels will pass clear starboard-to-starboard without a change of course. Pilot Rules cannot contradict Inland Rules, thus the Inland Rule prevails in a meeting situation. Three short blasts, according to Pilot Rules, mean: "My engines are going at full speed astern." This particular whistle signal, sounded in inland waters, is a signal of execution instead of intention.

Assume that one of two vessels crossing is backing down. Which is the burdened vessel? Each vessel has the other one either to port or to starboard. In a situation like this, the courts have held that, for the purpose of locating the burden of keeping clear, the vessel going astern is considered to have her bow where her stern actually is. Then, if the other ship is on her starboard side, facing aft, she herself must keep clear.

Under the Rule of Good Seamanship, you read about a situation in inland waters where a burdened vessel may signal to the privileged vessel to share the burden of keeping clear. The instance cited was a tug towing a string of barges in a following current on the port side of another vessel. In this example the single vessel sounds one short blast, indicating under the Pilot Rules an intention to maintain her right-of-way. The tug answers with the danger signal followed by two short blasts, signifying an intention to pass starboard-to-starboard. To let the tug cross, the single vessel must lie to or alter her course. Before the final maneuver, the single vessel must answer with two short blasts after she hears the tug's two short blasts. As a matter of fact, the courts have held, in a similar situation, that a vessel may sound the signal that, in effect, calls for a shift of the burden of keeping clear, before the privileged vessel sounds her original signal.

OVERTAKING

Any vessel, including a sailing vessel, overtaking another must keep clear of the overtaken vessel. An overtaking vessel is one that is approaching another vessel from any direction more than 2 points abaft her beam. When in doubt as to whether you are forward or abaft this bearing, you must assume that you are overtaking and keep clear.

In an overtaking situation, you recall, the Inland and International Rules have significant differences in whistle signals. In international waters a vessel that can pass another without a change of course sounds no signal. If she must change course, she sounds the appropriate signal as she does so. She is not required to wait for an answer.

In inland waters, however, an overtaking vessel cannot pass another ship until she signals on which side she intends to pass—one short blast if passing to starboard, two if passing to port. She sounds a signal regardless of whether she must change course, and she may not pass until she hears a repeat of the same signal from the vessel being overtaken.

If the ship being overtaken considers the proposed maneuver risky, she sounds the danger signal followed by the signal for what she considers the safer procedure. Assume that the overtaking vessel sounds one short blast, signifying an intention to pass to starboard. The ship being overtaken vetoes this by sounding the danger signal. She follows with two short blasts, meaning: "You had better pass me to port, instead." The overtaking vessel replies with two blasts and may then pass the other to port.

RADAR INFORMATION

When using radar information as an aid in navigation, the following recommendations should be applied.

1. Assumptions made on scanty information may be dangerous and should be avoided.

2. All vessels navigating in restricted visibility must go at a moderate speed. Information obtained from radar is one circumstance to consider when determining moderate speed. In this regard it must be realized that small vessels, small icebergs, and similar floating objects may not be detected by radar. Radar indications of one or more vessels in the vicinity may mean that "moderate speed" should be slower than a mariner navigating without radar might consider moderate in the circumstances.

3. When navigating in restricted visibility and a fog signal is heard forward of the beam, a ship's radar range and bearing along do not constitute ascertainment of the position of the other vessel sufficiently to relieve a ship of her duty to stop her engines and navigate with caution.

4. When action has been taken to avoid a close quarters situation, it is essential to make

sure that such action is having the desired effect. Alterations of course or speed or both are circumstances in which the mariner must be guided by the individual situation.

5. Alteration of course alone may be the most effective action to avoid close quarters if there is sufficient sea room, if it is made in good time, if it is substantial, and if it does not result in a close quarters situation with other vessels.

6. The direction of an alteration of course is a matter in which the mariner must be guided by the applicable circumstances. An alteration to starboard, particularly when vessels are approaching nearly on opposite courses, usually is preferable to an alteration to port.

7. An alteration of speed, either alone or in conjunction with an alteration of course, should be substantial so that other vessels may realize that you have taken some action. A number of small alterations of speed should be avoided.

8. If a close quarters situation is imminent, the most prudent action may be to take all way off the vessel.

CHANNELS, BENDS, AND LEAVING A BERTH

Both Inland Rules and International Rules say that in a narrow channel every steam vessel must, when it is safe and practicable, keep to the side of the fairway or midchannel lying to her own starboard. Inland Rules provide that a steam vessel approaching a bend in a channel, if she is unable to see for at least 1/2 mile ahead, must sound a long blast on her whistle, which must be answered by any approaching vessel that hears it. International Rules are the same except that a prolonged blast is sounded. If the first vessel receives no answer, she may consider the channel clear ahead. A long blast, by custom, is of 8 to 12 seconds' duration.

A vessel leaving her dock or berth also sounds a long blast in inland waters. Suppose a ship backing out into a fairway encounters a crossing situation with another coming down the fairway. Does the court's doctrine of changing ends to fix the burden of keeping clear apply? Apparently not. The courts have rules that when a ship is leaving her berth, the ordinary sailing rules do not apply until she is fully in sight. If she becomes involved with another ship, both ships must keep clear.

DISTRESS SIGNALS

Both Inland and International Rules stipulate that distress signals may be made either separately or together. There is no basis in the rules for the popular notion that the national ensign, hoisted upside down, is a recognized signal of distress. No man-of-war would ever subject the colors to this indignity. But if you should see a private craft with her ensign hoisted upside down, she probably is in distress, and you should go to her assistance without delay.

Distress signals under Inland Rules are as follows:

1. In the daytime, a continuous sounding with any fog-signal apparatus, or firing a gun.
2. At night–
    a. Flames on the vessel, as from a burning tar barrel or oil barrel.
    b. A continuous sounding with any fog-signal apparatus, or firing a gun.

Distress signals under International Rules are as follows:

1. A gun or other explosive signal fired at intervals of about 1 minute.
2. A continuous sounding with any fog-signal apparatus.
3. Rockets or shells, throwing red stars, fired one at a time at short intervals.
4. The signal group ...---... (SOS) in Morse code.
5. Radiotelephone signal "Mayday."
6. The international signal of distress indicated by the letters NC.
7. The distress signal, a square flag having above or below it a ball or anything resembling a ball.
8. Flames on the vessel, as from a burning tar barrel or oil barrel.
9. A rocket parachute flare or a hand flare showing a red light.

10. A smoke signal giving off a volume of orange-colored smoke.

11. Slowly and repeatedly raising and lowering arms outstretched to each side.

SPECIAL SUBMARINE SIGNALS

The following signals, although not part of the Rules of the Road, are prescribed for submerged submarines in emergency situations involving rising to periscope depth or surfacing.

1. A yellow smoke flare fired into the air from a submarine indicates the submarine is coming to periscope depth to carry out surfacing procedures. Ships should clear the immediate vicinity, but should not stop propellers.

2. A red smoke flare fired into the air from a submarine is a signal that the submarine is in serious trouble and will surface immediately if possible. Smoke flares of any color, fired into the air at short intervals, mean that the submarine requires assistance. All ships in the vicinity should stand by to give aid.

CHAPTER 7

CHARTS AND PUBLICATIONS

A chart is a pictorial representation of all or part of the navigable waters of the Earth. Before going into detail concerning information on charts, you should know the methods of projection by which the curved surface of the Earth's sphere is transferred to a flat plane. Best known is the Mercator system, devised several hundred years ago by a Flemish geographer whose real name was Gerhard Kremer. Most of the charts you will use are Mercator projections.

MERCATOR PROJECTION

If you cut a hollow rubber ball in half and try to flatten out one of the halves, you will find you cannot do so without tearing or stretching the rubber. In fact, no section of the hemisphere will lie flat without some distortion. Projection of the curved surface of the Earth onto a flat plane presents the same difficulty. No system has been devised for such a projection that preserves the true proportions of components of the original sphere. The surface of a cylinder, although derived mathematically, may be conceived—for the sake of simplicity—as being based upon this phenomenon.

The discussion that follows is general. Consult Dutton's Navigation and Piloting or the American Practical Navigator, Pub. No. 9 if you desire more detailed information.

In drawing a Mercator projection, the first detail is to project the meridians. Assume that the Earth is a hollow, transparent glass ball with a powerful light shining in its center. A paper cylinder is placed around it, tangent to it at the Equator, as shown in figure 7-1. Suppose the meridians painted on the glass ball are projected onto the cylinder as vertical lines, parallel to and equidistant from one another. (See figure 7-2.)

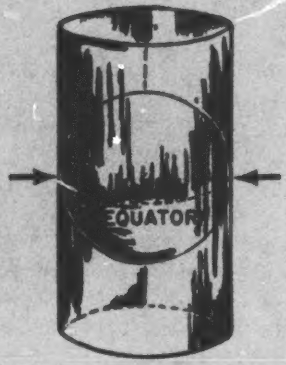


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Figure 7-1.—Cylinder tangent to the Earth at the Equator.

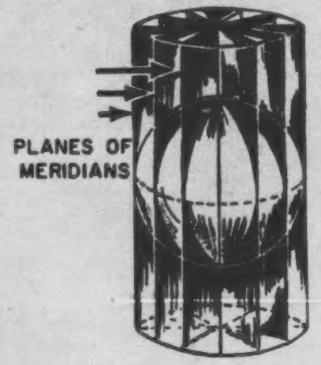

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Figure 7-2.—Projection of meridians on the cylinder.

The cylinder now has the meridians on its surface, and half of the Mercator projection is complete.

The next step in the projection process is to draw the parallels. Spacing of the parallels is derived mathematically to agree with the expansion of the longitude scale. Spacing between parallels increases progressively toward the poles at the same ratio as the expansion of the space between meridians. The meridians and parallels are at right angles to one another. Remember, because of the sphere-cylinder relationship, the North and South Poles cannot appear on the Mercator projection.

Now unroll the cylinder and look at the projection that has been made (figure 7-3). The meridians are parallel to and equidistant from one another. The latitude lines are parallel to one another, but they gradually draw apart as they become farther north and south of the Equator. Above or below 80° north or south latitude, they become so far apart that Mercator projections of the polar regions seldom are used.

Although the space between parallels on a Mercator chart increases with latitude, the distance represented by 1° of latitude is always nearly equal to 60N miles. One minute of latitude is usually considered to be 1 nautical mile.

On a Mercator projection, however, 1° of latitude near one of the poles appears considerably longer than 1° of latitude near the Equator. It follows, then, that if both measurements represent the same actual distance, that distance as shown in high latitude on a Mercator chart will appear distorted, but actually it conforms to scale.

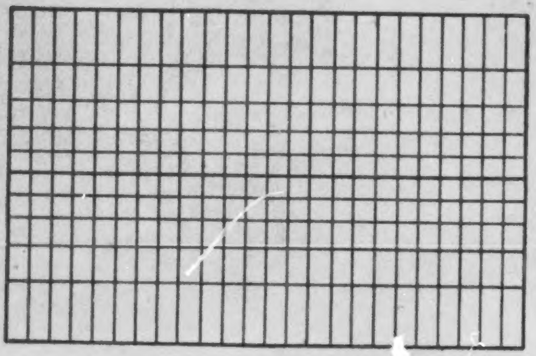

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Figure 7-3.—Meridians and parallels on a Mercator projection.

Figure 7-4 shows the globe with actual comparative size of Greenland to the United States. But on the Mercator chart in the background, Greenland appears to be larger than the United States. The reason is that at high latitudes the Mercator chart shows greater exaggeration of area, but the exaggeration conforms to the latitude and longitude scale. Actually the United States is a good deal larger than Greenland.

DIRECTION ON A MERCATOR PROJECTION

As mentioned before, the meridians on a Mercator chart appear as straight lines, parallel to and equidistant from one another. You know, however, that they represent imaginary curved lines, not parallel to one another at all but converging at the poles.

Appearance of meridians on a Mercator projection as parallel straight lines is one of the most valuable features of this type of projection, making it possible to plot a course as a straight line (called a rhumb line).

On a Mercator projection though, a rhumb line cuts every meridian at the same angle. In other words, it is a line of the same bearing throughout. Although it does not represent the shortest distance between the points it connects, this fact is not important unless very large distances are involved.

You may already know that the shortest distance between two points on a sphere is along the great circle connecting them. Such a line intersects every meridian at a different angle. A great circle, with the exception of a meridian or the equator, is a line of continuously changing direction, along which it would be generally impracticable to steer a ship. The ship's course would have to be changed progressively and continuously to follow it. That brings up the subject of great circle sailing, which is usually done from charts made by gnomonic projection.

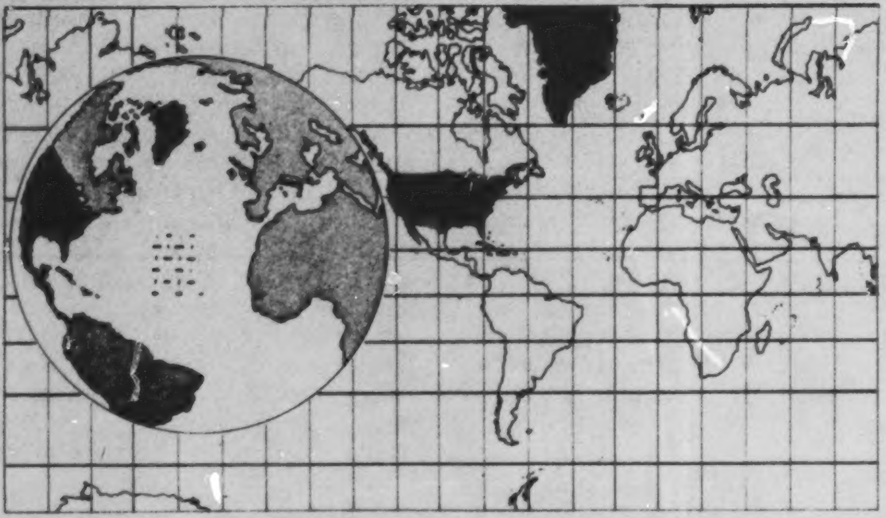


Figure 7-4.—Globe/Mercator chart comparison. 65.117

GNOMONIC PROJECTION

If a plane is tangent to the Earth, and points are projected geometrically from the center of the Earth, the result is a gnomonic projection. If the point happens to be one of the poles, then the parallels appear as a series of concentric circles, and the meridians are straight lines radiating away from the poles.

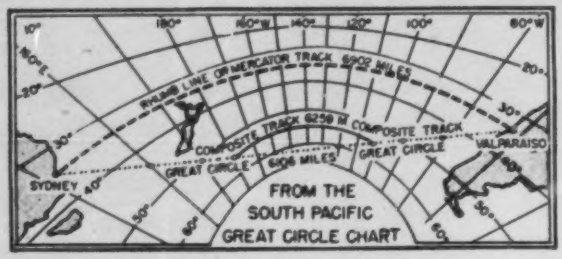
Polar charts frequently are gnomonic projections. Chief advantage of the gnomonic projection is in determining the great circle track (or shortest distance) between two widely separated points. Gnomonic projections utilized for this prupose are called great circle charts. Gnomonic projections cannot be used directly for navigation because, unlike the Mercator projection, they are not conformal projections; i.e., they do not show correct angular and spatial relationships.

GREAT CIRCLE SAILING

Suppose you are sailing from Valparaiso, Chile, to Sydney, Australia—a considerable distance. Time and expense can be saved if you sail by the shortest route. The shortest distance between any two points on the Earth is along the great circle passing through the points.

On a gnomonic projection, a great circle appears in a straight line (figure 7-5). Take out the great circle chart of the South Pacific, and connect Valparaiso and Sydney by a straight line. This line is the great circle track between those points. You can't steer along this track, however, because it is a line of continuously changing direction. Instead, you transfer the great circle course from the small-scale great circle to a series of larger-scale Mercator charts. Latitude and longitude of points along the great circle course are located on the Mercator charts and are connected by a series of straight rhumb lines. The rhumb lines indicate the courses the ship actually will steer.

Great circle sailing usually is performed only over a large area. For short distances, a rhumb line and great circle course very nearly coincide. Even for long distances, the course actually


10°
180°
160°W
140°
120°
100°
80°W
160°E
20°
RHUMB LINE OR MERCATOR TRACK 6902 MILES
20°
30°
30°
COMPOSITE TRACK 6250 M
COMPOSITE TRACK
COMPOSITE
GREAT CIRCLE
6106 MILES
GREAT CIRCLE
VALPARAISO
SYDNEY
40°
50°
60°
30°
60°
FROM THE
SOUTH PACIFIC
GREAT CIRCLE CHART

65.118(69)B

Figure 7-5.—Rhumb line and great circle course on a great circle chart.

steered is a composite of both tracks (figure 7-6), selected to avoid high latitudes and dangers to navigation.

SCALE OF CHARTS

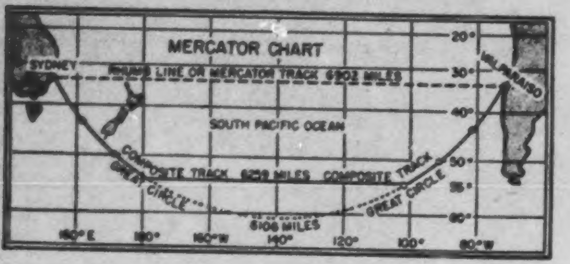
The scale of a chart refers to a measurement of distance, not area. A chart covering a relatively large area is called a small-scale chart and one covering a relatively small area is called a large-scale chart. Scales may vary from 1:2,500 for plans to 1:14,000,000 for world charts. Normally, the major types of charts fall within the following scales:

1. Harbor Charts–1:2,400 to 1:50,000
2. Coast and Approach Charts–1:50,000 to 1:100,000
3. Offshore Coasting Charts–1:100,000 to 1:600,000
4. Ocean Sailing Charts–1:600,000 or smaller

The size of the area portrayed by a chart varies extensively, according to the scale of the chart. (See figure 7-7.) The larger the scale, the smaller the area represented. From this truism it follows that large-scale charts show areas in greater detail. Many features that appear on a large-scale chart do not, in fact, show up at all on a small-scale chart of the same area.

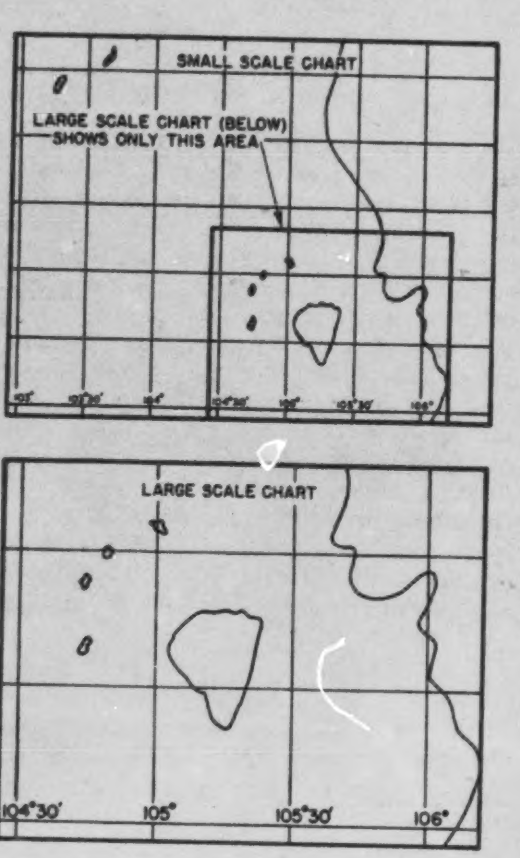
The scale to which a chart is drawn usually appears under its title in one of two ways: 1:5,000 or 1/5,000. The figures mean, in effect, that an actual feature is 5,000 times as large as its representation on the chart. Expressed another way, an inch, foot, yard, or the like, on the chart means 5,000 identical units on the Earth's surface. Thus, the larger the figure indicating the proportion of the scale, the smaller the scale of the chart. A chart with a scale of 1:5,000 is on a much larger scale, for instance, than one whose scale is 1:4,500,000. Another way of expressing scale, called the numerical scale, is in inches to the nautical mile.

You must exercise greater caution when working with small-scale charts than with large-scale charts. A small error, which may be only a matter of yards on a large-scale chart, could amount to miles on a chart depicting a


MERCATOR CHART
SYDNEY
RHUMB LINE OR MERCATOR TRACK 6202 MILES
VALPARAISO
SOUTH PACIFIC OCEAN
COMPOSITE TRACK
COMPOSITE TRACK
GREAT CIRCLE
GREAT CIRCLE
6106 MILES
20°
30°
40°
50°
55°
60°
160°E
180°
160°W
140°
120°
100°
80°W

65.118(69)A

Figure 7-6.—Rhumb line and great circle course on a Mercator chart.


SMALL SCALE CHART
LARGE SCALE CHART (BELOW) SHOWS ONLY THIS AREA
103°
103°30'
104°
104°30'
105°
105°30'
106°
LARGE SCALE CHART
104°30'
105°
105°30'
106°

65.123

Figure 7-7.—Small-scale and large-scale charts.

much more extensive area. When navigating the approaches to land, use only charts of the largest scale.

TYPES OF CHARTS

Charts used in the Navy may be prepared by the Defense Mapping Agency Hydrographic Center, DMAHC; the National Ocean Survey, NOS (formerly Coast and Geodetic Survey); the British Admiralty; or by other agencies. Whatever the source, all charts used by the Navy are issued by the Defense Mapping Agency (DMA).

NAVIGATIONAL CHARTS

A navigational chart is one on which standard symbols, figures, and abbreviations give information on depth of water, character of bottom and shore, location of navigational aids, and other information used in actual navigation.

General sailing charts are small-scale charts showing the approaches to large areas of the coast. These charts show offshore soundings, principal lights and outer buoys, and any natural landmarks visible at a considerable distance. The scale of general sailing charts usually is 1:600,000 and smaller.

Coastal charts are on a larger scale. They are used to navigate a vessel that is well offshore but whose position may be determined by prominent landmarks and lights, outer buoys, or soundings. When navigating inside outlying reefs or shoals, or well offshore in large bays or sizable inland waterways, a coastal or harbor chart may be used.

Harbor charts are on scales larger than 1:50,000. They show harbors and their approaches in considerable detail.

Soundings

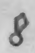
Scattered all over the watery area of any navigational chart are many tiny figures, each number representing the depth of water (usually the depth of mean low water) in that particular locality. Depths on charts are given in feet, fathoms, or meters. A notation under the title of the chart is the key; for example, "Soundings in feet at mean low water" or "Soundings in fathoms at. . . ." Most charts also contain dotted lines called fathom curves, marking the limits of areas of certain depths. On the chart in figure 7-8 you can see a 10-fathom (60 feet) curve and a 15-fathom (90 feet) curve.

On all new charts produced, water depths and heights of lights will be in meters; land contours will also be shown in meters, except where the source data is expressed in feet.

Aids to Navigation

Aids to navigation are indicated on a chart by appropriate symbols. As much information as possible is printed in standard abbreviations near the symbol. For instance, look at the light on Castle Hill, on the west point of Newport Neck (figure 7-8). Printed near the light symbol is this information: E int R 6 sec 40 ft 10M Horn. This notation means the light is red, it is of equal interval (the light having equal durations of light and darkness), the period required for the light to go through a complete cycle is 6 seconds, the light is 40 feet above mean high water and has a nominal range of 10 nautical miles. It is also equiped with a fog-signaling apparatus of a horn.

The chart symbol for a buoy is a diamond shape. Notice that there is a small dot near every buoy symbol. This dot represents the buoy's approximate location.

A new optional buoy symbol  has been adopted. It is used to better portray the fact that a buoy symbol indicates the approximate positions.

PILOT CHARTS

Pilot charts, prepared by the DMAHC, are rather curiously named. They are small-scale charts of large areas, thus they are of little use in actual piloting. Nevertheless, they are invaluable to navigators. They present, in graphic form, a complete review of the hydrographic, navigational, and meteorological situation in a given area. Included is information concerning average winds, tides, currents, and barometer readings; frequency of storms, calms, or fog; possibility of the presence of ice, wrecks, or other dangers; and location of ocean station vessels. Lines of equal magnetic variations are given for each full degree of variation. Indicated also are the shortest and safest routes between principal ports.

Pilot Chart of the North Atlantic Ocean and Pilot Chart of the North Pacific Ocean are issued monthly by the DMAHC. Other pilot charts are published in atlas form for the Northern North Atlantic Ocean, the South Atlantic Ocean and Central American Waters, and the South Pacific and Indian Oceans.

AVIATION CHARTS

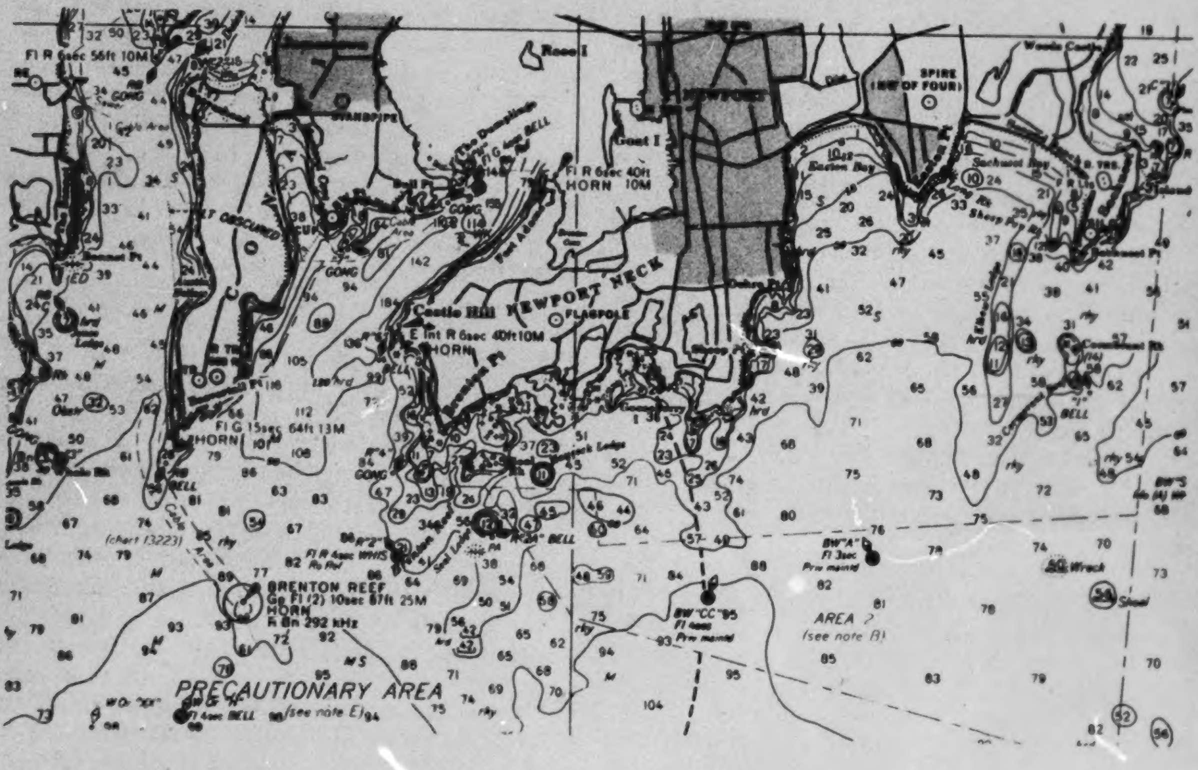
All naval air stations, facilities, and aircraft tenders keep a permanent file of one set of aviation charts and publications for the areas in which their aircraft may be called upon to operate. A complete file of DOD Aeronautical Chart Updating Manual (CHUM), DOD Aeronautical Chart Bulletin, and DOD Aeronautical Chart Bulletin Digest must be maintained by each of the aforementioned activities.

The CHUM is published monthly and the latest edition always supersedes that of the previous month. The Aeronautical Chart Bulletin is published monthly and should be accumulated for 6 months until superseded by the DOD Aeronautical Chart Bulletin Digest.

The permanent file of aviation charts and publications must be corrected and kept up to date at all times, reflecting all pertinent changes as published in the CHUM. The same general principles of correction apply as are employed in nautical charts.

UNITED STATES NAUTICAL CHART NUMBERING SYSTEM

The Unites States Nautical Chart Numbering System applies to all nautical charts produced by the DMAHC and the NOS. The chart numbering system provides a simple method of


NEWPORT NECK
Castle Hill
Goat I
Rose I
BRENTON REEF
PRECAUTIONARY AREA
(see note E)
AREA 2
(see note B)
(chart 13223)
HORN
BELL
GONG
Fl R 6sec 40ft HORN 10M
F1 G 15sec 64ft 13M
SPIRE
Wreck
Shoal

69.29

Figure 7-8.—Part of chart 13218.

identifying each chart by number which indicates, in general, the geographical region and scale range in which the chart falls. Charts numbered with one to five digits, as shown in the following lists.

Number of Digits	Natural Scale
ONE (1-9)	No scale involved
TWO (10-99)	1:9,000,001 and smaller
THREE (100-999)	1:2,000,001 to 1:9,000,000
FOUR (5000-9999)	Non-navigational type
FIVE (11000-99999)	1:2,000,000 and larger

From the list indicating number of digits and associated scale, four categories of charts exist. Each category contains clues to the location and scale range of the chart.

The prefix N.O. is being removed as new charts are issued. The first category, which contains charts with one-digit numbers, has no scale and includes such charts as Nautical Chart Symbols and Abbreviations, chart (1); National Flags and Ensigns, chart (5); International Flags and Pennants with Morse Symbols, chart (6).

The second category has charts with two- and three-digit numbers that are general charts based on the nine "ocean basin" concept. (See (figure 7-9.) The ocean basins of the world are as follows:

Basin	Area
1	North Atlantic
2	South Atlantic
3	Mediterranean
4	Caribbean
5	North Pacific Ocean
6	South Pacific Ocean
7	Indian Ocean
8	Arctic Ocean
9	Antarctica

The first digit in the category denotes the ocean basin which the chart covers. Two-digit numbers (10-99) are used for charts with a scale 1:9,000,001 and smaller, while the three-digit numbers (100-999) indicate charts with a scale between 1:2,000,001 and 1:9,000,000. An exception to the scale concept is the series of position plotting sheets, which have a scale larger than 1:2,000,000. These plotting sheets have been included in the three-digit number category because they cover ocean basins of 360° of longitude. Since the Mediterranean (basin 3), the Caribbean (basin 4), and the Indian Ocean (basin 7), for example, are small in size, an exception to the ocean basin concept exists. There is no chart smaller in scale than 1:9,000,000 in these areas. The two-digit numbers 30 to 49 and 70 to 79 are used for special world charts that cannot have the first digit indicating an ocean basin, such as The Magnetic Inclination or Dip, chart (30); Magnetic Variation, chart (42); and the Standard Time Zone Chart of the World, chart (76).

The third category consists of non-navigational charts with four-digit numbers. They are a special-purpose chart series such as chart 5006, Chart of the World, Longitude 172°W to 15°E; and chart 5090, Maneuvering Board.

The fourth category contains charts with five-digit numbers. Since the charts in this category have a scale range of 1:2,000,000 and larger, the "ocean basin" concept loses significance. So another system was adopted, based on the world now divided into nine regions as follows:

Region	General Area
1	United States and Canada
2	Central and South America and Antarctica
3	Western Europe, Iceland, Greenland, and the Artic
4	Scandinavia, Baltic, and U.S.S.R.
5	West Africa and the Mediterranean
6	Indian Ocean
7	Australia, Indonesia, and New Zealand
8	Oceania
9	East Asia

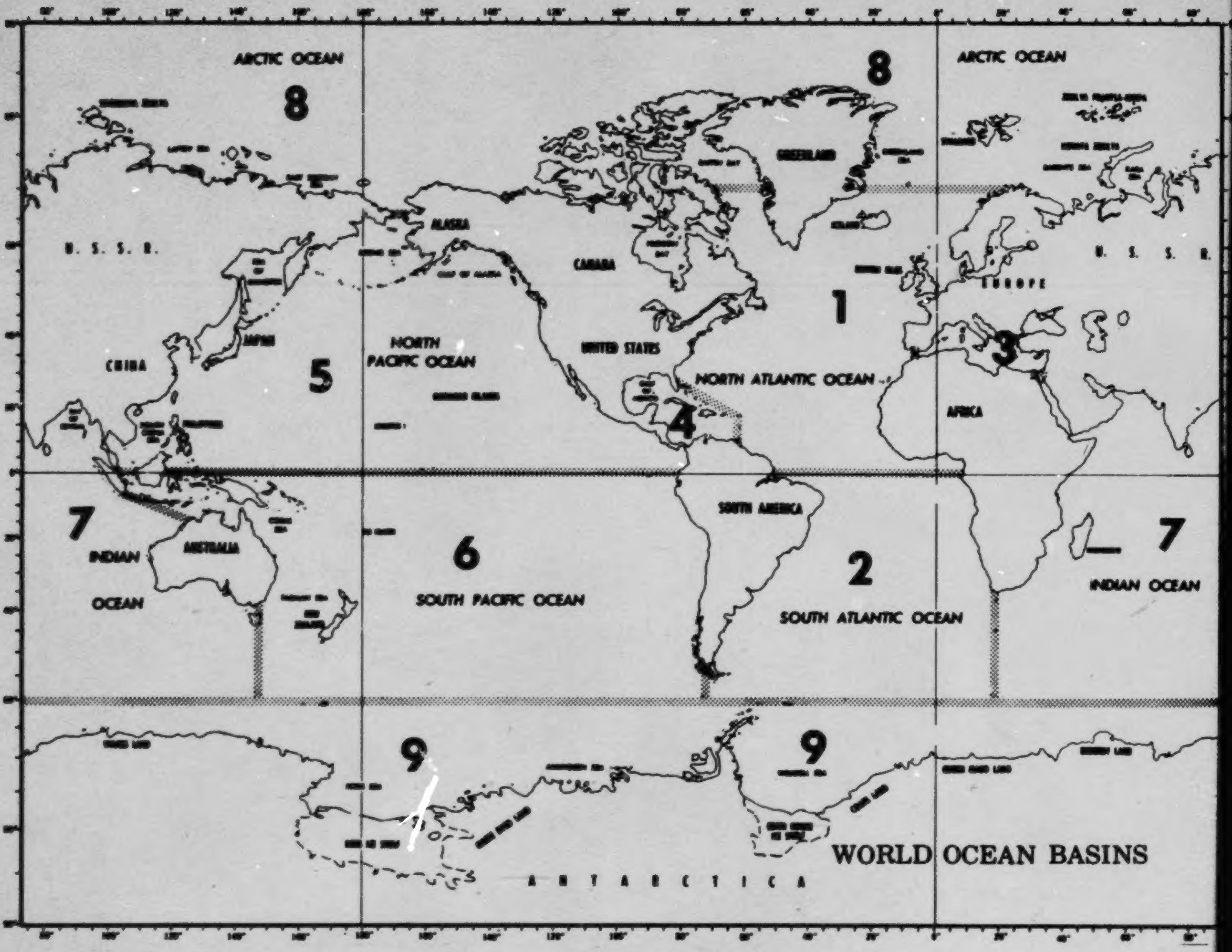
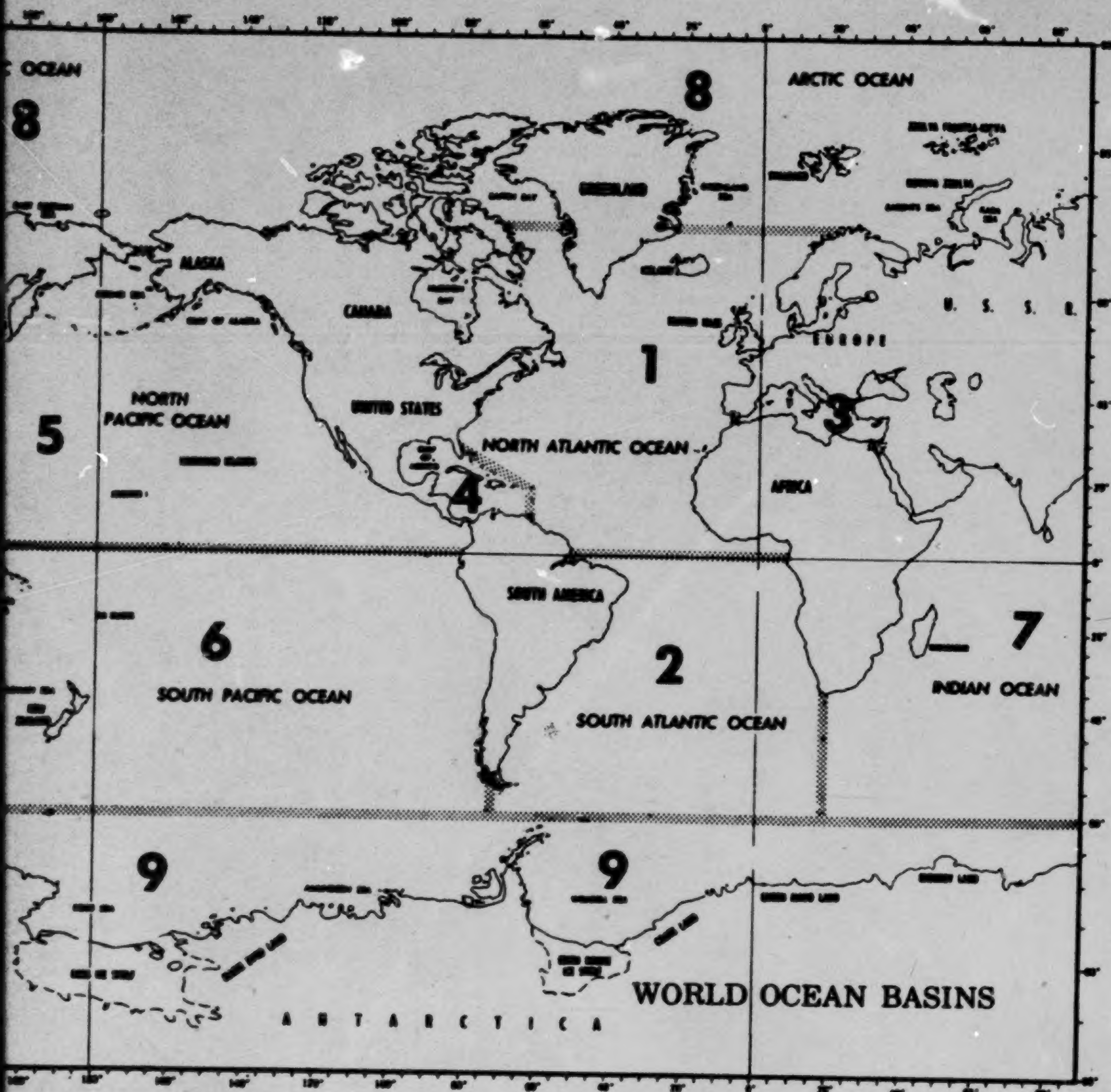

ARCTIC OCEAN
8
8
ARCTIC OCEAN
GREENLAND
U. S. S. R.
ALASKA
CANADA
U. S. S. R.
EUROPE
1
3
CHINA
JAPAN
5
NORTH PACIFIC OCEAN
UNITED STATES
NORTH ATLANTIC OCEAN
AFRICA
4
SOUTH AMERICA
7
INDIAN OCEAN
AUSTRALIA
6
SOUTH PACIFIC OCEAN
2
SOUTH ATLANTIC OCEAN
7
INDIAN OCEAN
9
9
ANTARCTICA
WORLD OCEAN BASINS

Figure 7-9.—World ocean basins.


OCEAN
8
8
ARCTIC OCEAN
GREENLAND
ALASKA
CANADA
U. S. S. R.
EUROPE
1
NORTH
PACIFIC OCEAN
5
UNITED STATES
3
NORTH ATLANTIC OCEAN
4
AFRICA
SOUTH AMERICA
6
2
7
SOUTH PACIFIC OCEAN
INDIAN OCEAN
SOUTH ATLANTIC OCEAN
9
9
ANTARCTICA
WORLD OCEAN BASINS

74.263

Figure 7-9.—World ocean basins.

Each region is further subdivided into numbered subregions. The subregions divide the world into 52 geographical areas which are assigned a two-digit designator. (See figure 7-10.)

The five-digit category contains all of the large-scale charts of the world. These are the primary nautical charts. The first of the five digits indicates the region in which the chart is depicted, the second digit indicates a geographical subregion within the region, and the last three digits identify the geographical order of the chart within the subregion.

There are exceptions to the chart numbering system just described, such as Bathymetric (Bottom Contour) and Non-Submarine Contact Charts. These charts, at a scale larger than 1:2,000,000, do not portray portions of a coastline, but chart parts of the ocean basins. In view of the characteristics of these charts, they are identified with an alphabetical character plus four digits: The letter "B" denoting bottom contour (BC) charts with or without Loran-A; the letter "C" for bottom contour charts with Loran-C information; the letter "N", non-submarine contact (NSC) charts; the letter "M", NSC charts containing Loran-C. The first digits of these charts describe the longitude band, and the last two digits describe the latitude band.

Combat charts also fall within the five-character identifier. However, because of their special military use, some deviation was made to distinguish them from regular navigational charts. Their five-character identifier consists of the two digits indicating the region and subregion in which the chart falls, the third character is a letter, and the final two characters are digits identifying the geographical sequence of the chart.

This numbering system is also applicable to nautical charts produced by foreign governments which the DMAHC maintains within its distribution system.

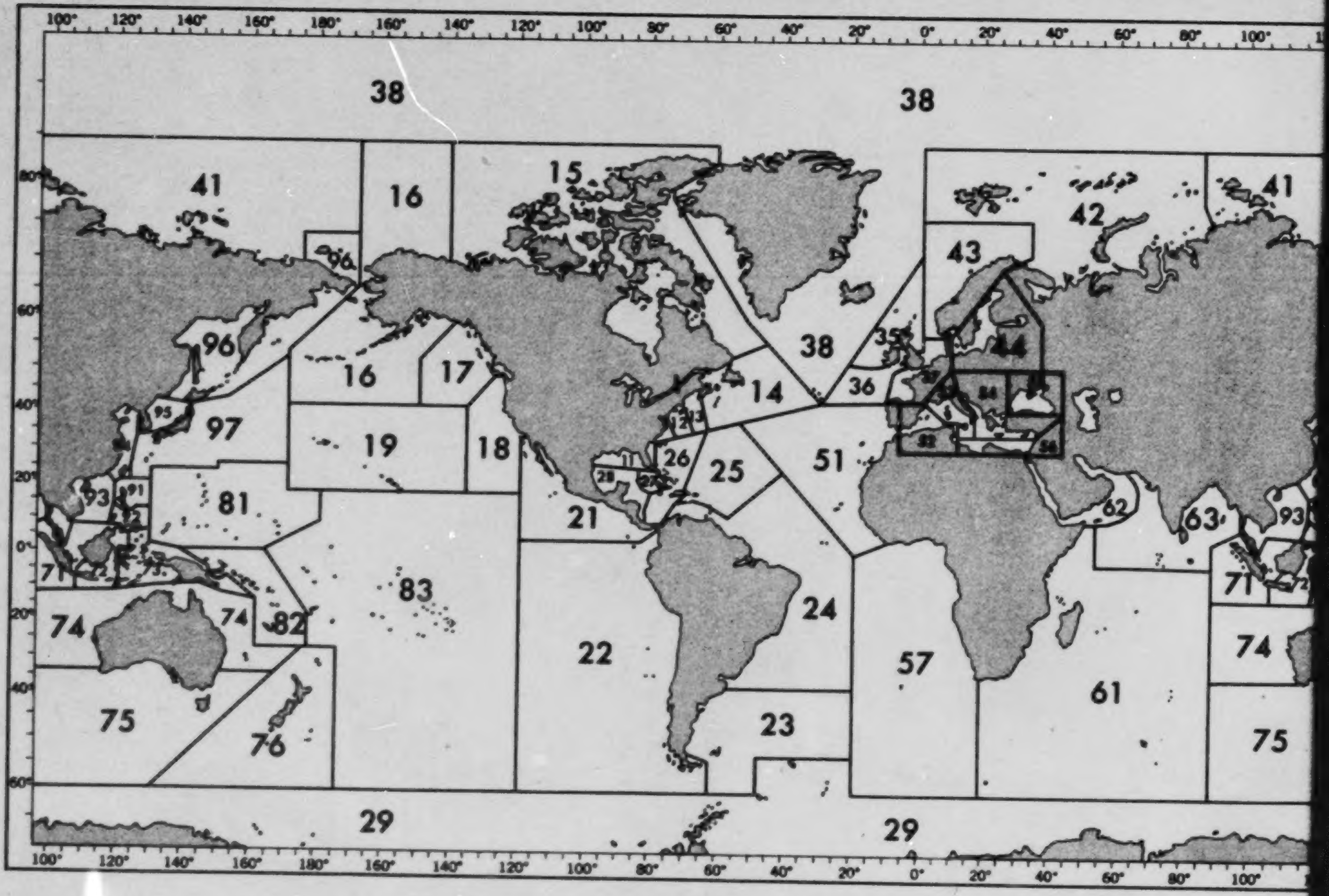
The charts your ship has on board depend on your ship type (CV, DD, LST, etc.). The allowance of charts for each type of ship is prepared by taking into consideration its probable operating range and its facilities for chart storage. For each type of ship assigned to units of the Atlantic of Pacific Fleets, you will find the minimum chart allowance listed in Pub. No. 1-PCL.

Quantities designated are basic minimum allowances. Your ship may carry additional charts, depending on your particular area of operation or the type of fleet commander's instructions.

PUBLICATIONS AND CATALOGS

Nautical charts and publications may be found indexed in one of the below listed catalogs. These catalogs can provide additional information of interest to the navigator that may not be found in Pub. No. 1-PCL.

Catalog No.	Contents
Pub. No. 1-N-A	General information on the catalog, graphics showing regions covered by Lists of Lights and Sailing Directions, a listing of Loran and Omega charts and plotting and display charts. Instructions and forms for ordering charts and publications.
Pub. No. 1-N-L	Complete numerical listing of charts issued by DMA Hydrographic Center. Standard terminology for DMA Hydrographic Center and National Ocean Survey charts.
Pub 1-N, REGION 1	United States and Canada
Pub 1-N, REGION 2	Central and South America and Antarctica
Pub 1-N, REGION 3	Western Europe, Iceland, Greenland, and the Arctic
Pub 1-N, REGION 4	Scandinavia, Baltic, and U.S.S.R.


100° 120° 140° 160° 180° 160° 140° 120° 100° 80° 60° 40° 20° 0° 20° 40° 60° 80° 100°
38
38
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16
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96
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97
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25
11
81
28
27
93
91
21
62
63
93
71
73
83
24
71
72
74
74
82
22
57
61
74
75
76
23
75
29
29
80°
60°
40°
20°
0°
20°
40°
60°

Figure 7-10.—World regions and subregions.

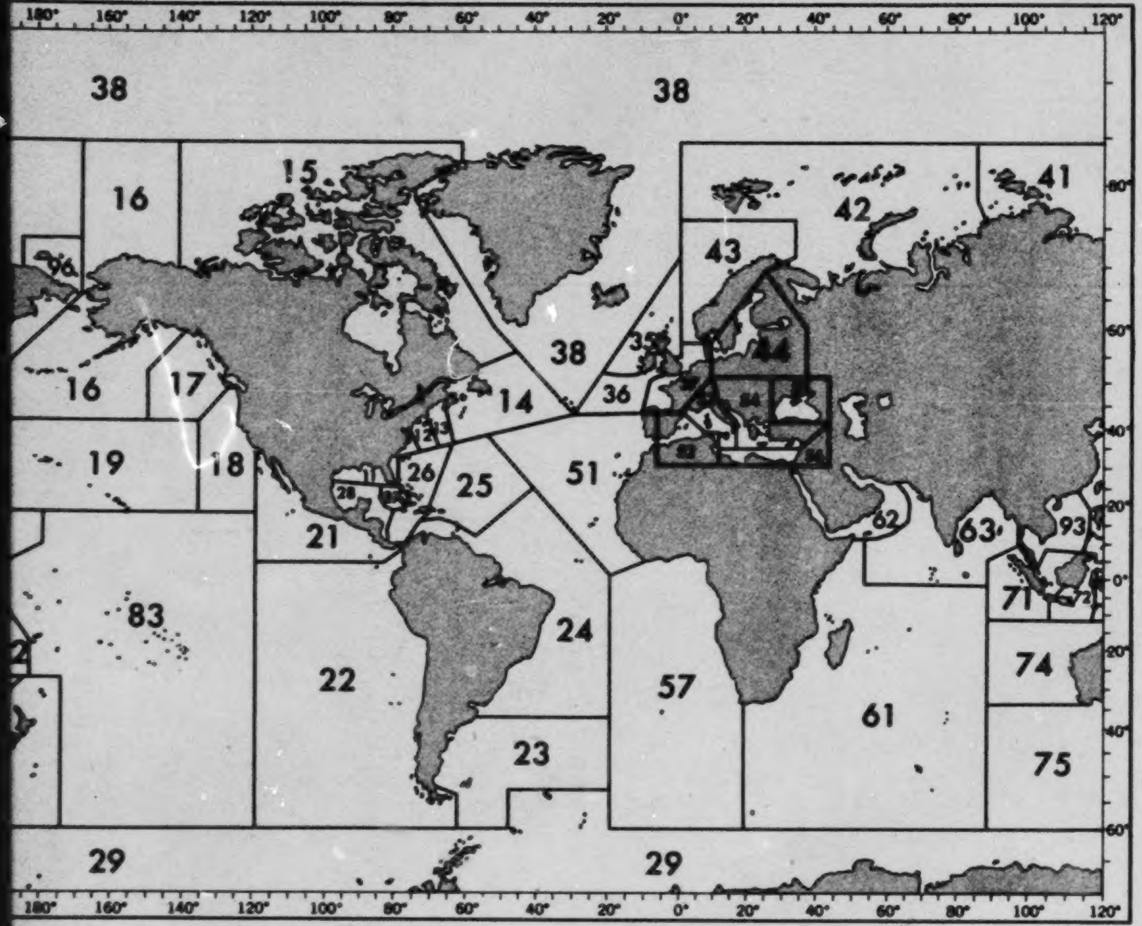

180°
160°
140°
120°
100°
80°
60°
40°
20°
0°
20°
40°
60°
80°
100°
120°
80°
60°
40°
20°
0°
20°
40°
60°
38
38
16
15
96
42
41
43
38
35
44
16
17
14
36
12
13
19
18
26
25
51
28
27
21
62
63
93
71
72
83
24
22
57
61
74
23
75
29
29

Figure 7-10.—World regions and subregions.

74.264

Catalog No.	Contents
Pub 1-N, REGION 5	West Africa and the Mediterranean
Pub 1-N, REGION 6	Indian Ocean
Pub 1-N, REGION 7	Australia, Indonesia, and New Zealand
Pub 1-N, REGION 8	Oceania
Pub 1-N, REGION 9	East Asia

Suppose you are to sail from Norfolk, Va., to Sao Luis in South America. For general planning and for sailing the open sea between the two ports, you would refer to Pub. No. 1-N-A to locate the appropriate small-scale charts, Sailing Directions, Light Lists, any charts needed for loran navigation, and position plotting sheets. For the large-scale charts needed when you navigate in port, channels, etc., you would refer to region 2.

Additions and changes to the catalogs may be obtained from the Notice to Mariners.

The National Ocean Survey Catalog of Aeronautical Charts and Related Publications, and the DOD Catalog of Aeronautical Charts and Flight Information Publications contain index plates and listings of aeronautical charts and publications. The charts are used principally for aeronautical navigation.

Only the latest editions of charts are issued. All charts issued by the depots will be corrected through NM 26/75 after which corrections will no longer be applied. All charts are corrected as of the print date shown in the lower left corner of the chart. Corrections affecting charts after the issue date are published in the weekly Notice to Mariners. All Navy ships receive the Notice to Mariners.

PORTFOLIO CHART LIST

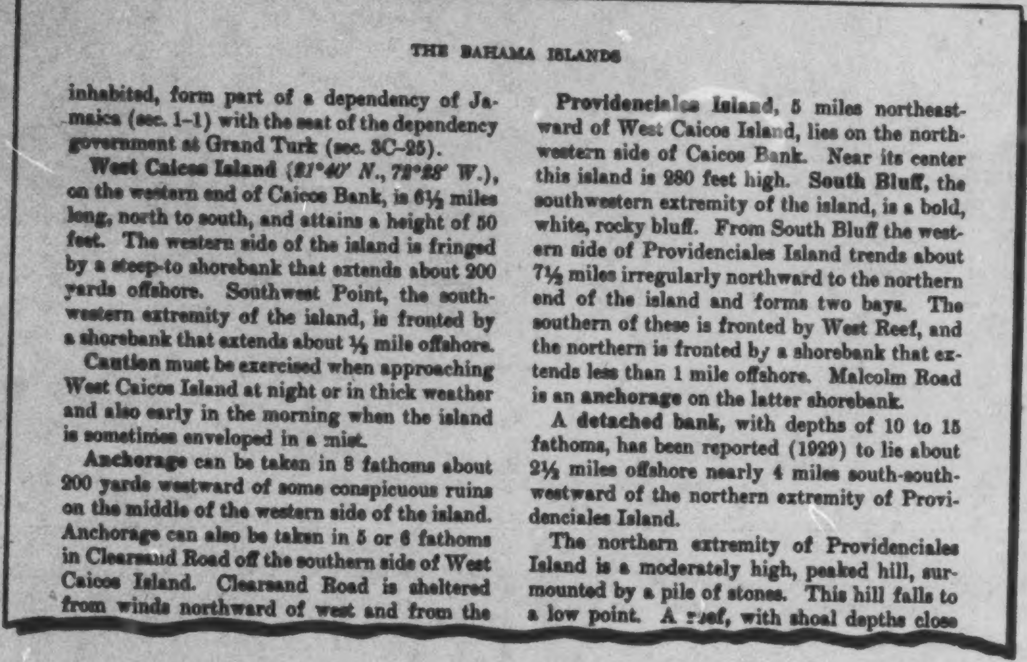
The Portfolio Chart List (Pub. No. 1-PCL) is a publication furnished by the DMAHC to United States ships. It is issued in two volumes; one for the Atlantic side of the world and one for the Pacific side. The ocean of operation determines which volume is issued to a particular ship. This publication contains a complete list of charts, by portfolio, arranged according to their numbers. The basic minimum charts and publication allowance for active vessels assigned to the Pacific or Atlantic Fleets is listed in Section 6 labeled For Official Use Only. Each ship may carry additional charts, depending on the particular area of operation, or according to instructions from type or fleet commanders.

The Portfolio Chart List is intended as a guide in selection and stowage of nautical charts aboard ship, and provides a ready reference to the grouping by geographic sequence of the charts in the various portfolios. Most of the necessary information concerning charts, such as chart number, edition number and date, and title required by a mariner in establishing a chart correction card system, is included within this publication

For nautical charts of the Great Lakes and adjacent waters, reference should be made to the National Ocean Survey Nautical Chart Catalog 4. This catalog may be issued by the DMAHC to the U.S. Navy and other authorized users. All other users may obtain this catalog from the Distribution Division (C44) (N.O.A.A.), Riverdale, Maryland 20840.

COAST PILOT AND SAILING DIRECTIONS

Similar information is given in the United States Coast Pilot (N.O.A.A.) and Sailing Directions (DMAHC). Whereas Coast Pilot applies to the United States and its possessions, Sailing Directions pertain to the rest of the world. New volumes are issued from time to time. Examples from these publications are shown in figures 7-11 and 7-12. Typical information in both publications includes pilotage, appearance of coastline (mountains, landmarks, visible foliage, etc.); navigational aids in general; local weather conditions; tides and currents; local rules of the road, if any; bridges-type, and clearance; anchorage facilities; repair facilities; availability of fuel and



THE BAHAMA ISLANDS

inhabited, form part of a dependency of Jamaica (sec. 1-1) with the seat of the dependency government at Grand Turk (sec. 3C-25).

West Caicos Island (*21°40' N., 72°28' W.*), on the western end of Caicos Bank, is 6½ miles long, north to south, and attains a height of 50 feet. The western side of the island is fringed by a steep-to shorebank that extends about 200 yards offshore. Southwest Point, the southwestern extremity of the island, is fronted by a shorebank that extends about ½ mile offshore.

Caution must be exercised when approaching West Caicos Island at night or in thick weather and also early in the morning when the island is sometimes enveloped in a mist.

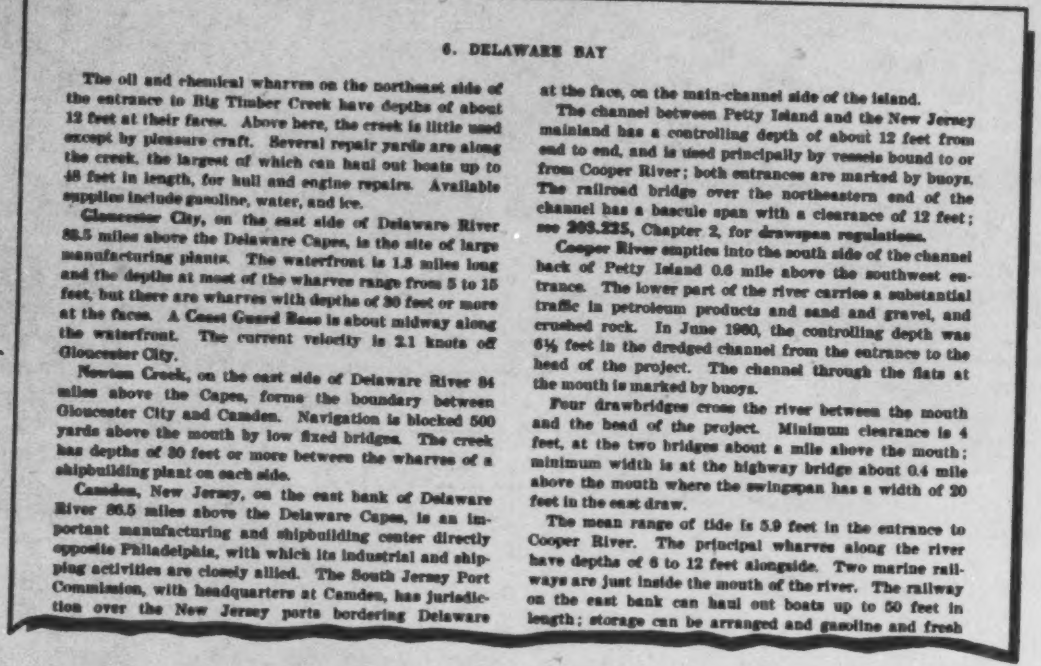
Anchorage can be taken in 8 fathoms about 200 yards westward of some conspicuous ruins on the middle of the western side of the island. Anchorage can also be taken in 5 or 6 fathoms in Clearsand Road off the southern side of West Caicos Island. Clearsand Road is sheltered from winds northward of west and from the

Providenciales Island, 5 miles northeastward of West Caicos Island, lies on the northwestern side of Caicos Bank. Near its center this island is 280 feet high. **South Bluff**, the southwestern extremity of the island, is a bold, white, rocky bluff. From South Bluff the western side of Providenciales Island trends about 7½ miles irregularly northward to the northern end of the island and forms two bays. The southern of these is fronted by West Reef, and the northern is fronted by a shorebank that extends less than 1 mile offshore. Malcolm Road is an **anchorage** on the latter shorebank.

A **detached bank**, with depths of 10 to 15 fathoms, has been reported (1929) to lie about 2½ miles offshore nearly 4 miles south-southwestward of the northern extremity of Providenciales Island.

The northern extremity of Providenciales Island is a moderately high, peaked hill, surmounted by a pile of stones. This hill falls to a low point. A reef, with shoal depths close

Figure 7-11.—Sample taken from Sailing Directions. 69.32



6. DELAWARE BAY

The oil and chemical wharves on the northeast side of the entrance to Big Timber Creek have depths of about 12 feet at their faces. Above here, the creek is little used except by pleasure craft. Several repair yards are along the creek, the largest of which can haul out boats up to 48 feet in length, for hull and engine repairs. Available supplies include gasoline, water, and ice.

Gloucester City, on the east side of Delaware River 88.5 miles above the Delaware Capes, is the site of large manufacturing plants. The waterfront is 1.8 miles long and the depths at most of the wharves range from 5 to 15 feet, but there are wharves with depths of 30 feet or more at the faces. A Coast Guard Base is about midway along the waterfront. The current velocity is 2.1 knots off Gloucester City.

Newton Creek, on the east side of Delaware River 84 miles above the Capes, forms the boundary between Gloucester City and Camden. Navigation is blocked 500 yards above the mouth by low fixed bridges. The creek has depths of 30 feet or more between the wharves of a shipbuilding plant on each side.

Camden, New Jersey, on the east bank of Delaware River 86.5 miles above the Delaware Capes, is an important manufacturing and shipbuilding center directly opposite Philadelphia, with which its industrial and shipping activities are closely allied. The South Jersey Port Commission, with headquarters at Camden, has jurisdiction over the New Jersey ports bordering Delaware

at the face, on the main-channel side of the island.

The channel between Petty Island and the New Jersey mainland has a controlling depth of about 12 feet from end to end, and is used principally by vessels bound to or from Cooper River; both entrances are marked by buoys. The railroad bridge over the northeastern end of the channel has a bascule span with a clearance of 12 feet; see **203.225**, Chapter 2, for drawspan regulations.

Cooper River empties into the south side of the channel back of Petty Island 0.6 mile above the southwest entrance. The lower part of the river carries a substantial traffic in petroleum products and sand and gravel, and crushed rock. In June 1960, the controlling depth was 6½ feet in the dredged channel from the entrance to the head of the project. The channel through the flats at the mouth is marked by buoys.

Four drawbridges cross the river between the mouth and the head of the project. Minimum clearance is 4 feet, at the two bridges about a mile above the mouth; minimum width is at the highway bridge about 0.4 mile above the mouth where the swingspan has a width of 20 feet in the east draw.

The mean range of tide is 5.9 feet in the entrance to Cooper River. The principal wharves along the river have depths of 6 to 12 feet alongside. Two marine railways are just inside the mouth of the river. The railway on the east bank can haul out boats up to 50 feet in length; storage can be arranged and gasoline and fresh

Figure 7-12.—Sample taken from Coast Pilot, Atlantic Coast. 69.33

provisions; transportation service ashore; and local industries.

NOTE: Under a new concept, begun in 1971, the 70 volumes of existing Sailing Directions are being replaced by 44 publications; namely, 35 new graphic Sailing Directions (Enroute), eight new Sailing Directions (Planning Guide).

Typical contents of the new Sailing Directions are shown below.

Sailing Directions (Enroute)

Table of Contents

SECTOR 1 - West Point to East Point

Chart information graphic

Coastal Winds & Currents

Outer Dangers

Coastal Features

Anchorages (Coastal)

Major Ports

Directions; Landmarks; Navaids; Depths; Limitations; Restrictions; Pilotage; Regulations; Winds; Tides; Currents; Anchorages

NOTE: Port facilities have been omitted from the new format. They are tabulated in the new expanded World Port Index.

Index - Gazetteer

Navigational features and place names are listed alphabetically in the back of the book. The Sector No. and approximate coordinates are listed to facilitate reference to the best scale chart shown on the Chart Information graphic.

NOTE: Many names in the Index - Gazetteer are included as a gazetteer feature. Only those names with page references are described in the text.

Sailing Directions
(Planning Guide)

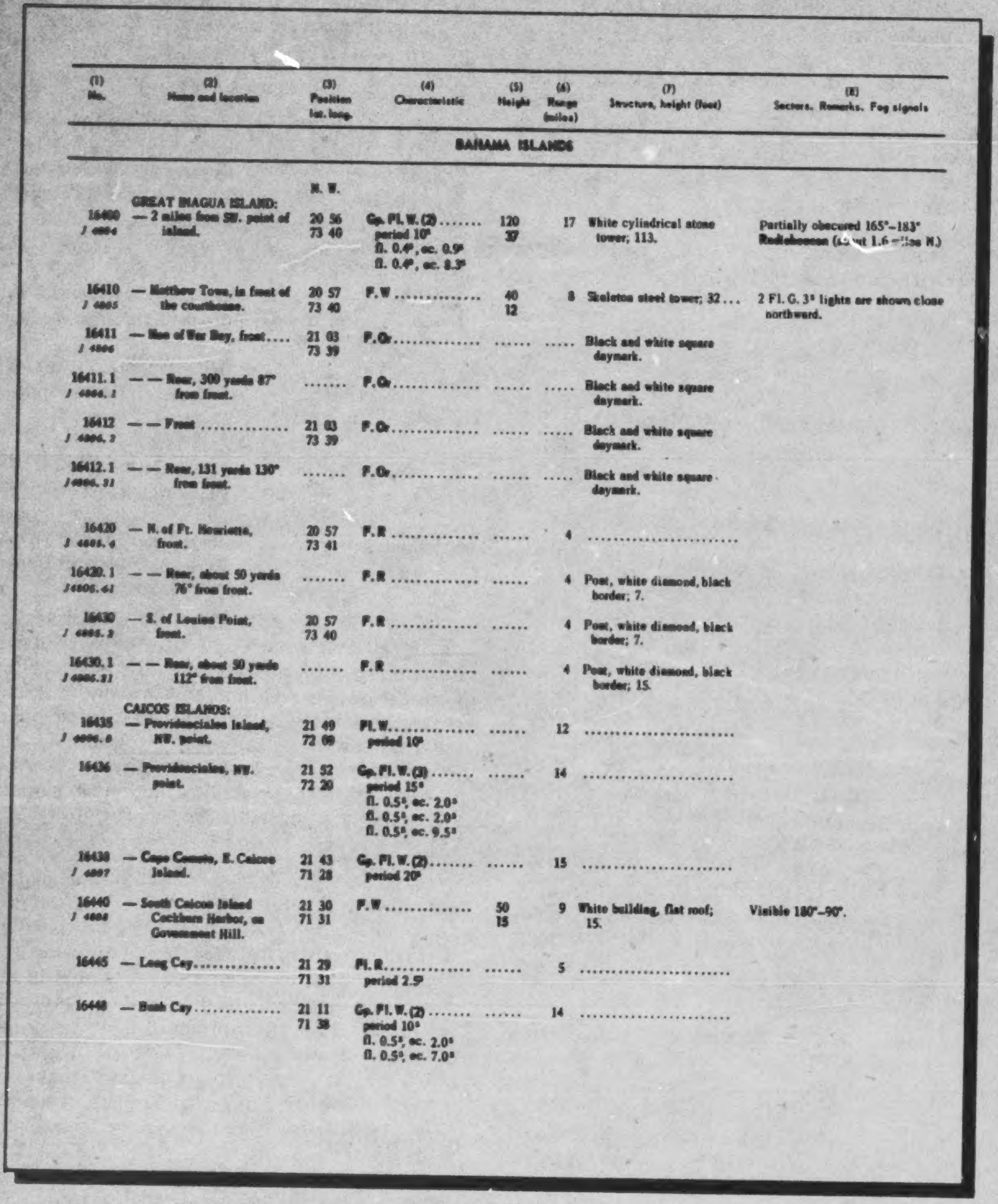
Chapter	Information Covered
1. Countries	Governments, Regulations, Search & Rescue, Communications, Pratique, Pilotage.
2. Ocean Basin Environment	Oceanography, Climatology, Magnetic Disturbances
3. Warning Areas	Operating Areas, Firing Areas, Reference Guide to Warnings, Cautions
4. Ocean Routes	Route Chart & Text, Traffic Separation Schemes
5. Navaid Systems	Electronic Navigation Systems, Systems of Lights & Buoyage

Coast Pilot, besides its standard information on United States ports and waterways, contains descriptions of ports and harbors; pilot information; quarantine and marine hospital information; Coast Guard stations; radio services; distances and bearings; time signals; atmospheric pressure, temperature, and wind tables; rules of the road; instructions in case of shipwreck; and general harbor regulations.

LIGHT LISTS

Use of light lists as a navigational aid is described in chapter 5 of this book. The Defense Mapping Agency Hydrographic publication List of Lights contains detailed information on the location and characteristics of every light in the world not located in the United States or possessions. Brief descriptions of lighthouses and fog signals are included. List of Lights is published in seven volumes, and they are corrected through Notice to Mariners. A sample page from a current issue is reproduced in figure 7-13.

Information on lights located on the continental coasts of the United States or its possessions, or in any of the United States



(1) No.	(2) Name and location	(3) Position lat. long.	(4) Characteristic	(5) Height	(6) Range (miles)	(7) Structure, height (feet)	(8) Sectors. Remarks. Fog signals
			BAHAMA ISLANDS				
		N. W.					
	GREAT INAGUA ISLAND:						
16400 *J 4804*	— 2 miles from SW. point of island.	20 56 73 40	Gp. Fl. W. (2) .... period 10^s fl. 0.4^s, ec. 0.9^s fl. 0.4^s, ec. 8.3^s	120 37	17	White cylindrical stone tower; 113.	Partially obscured 165°–183° Radiobeacon (about 1.6 miles N.)
16410 *J 4805*	— Matthew Town, in front of the courthouse.	20 57 73 40	F. W	40 12	8	Skeleton steel tower; 32 ...	2 Fl. G. 3^s lights are shown close northward.
16411 *J 4806*	— Man of War Bay, front	21 03 73 39	F. Or	......	.....	Black and white square daymark.	
16411.1 *J 4806.1*	— — Rear, 300 yards 87° from front.	....	F. Or	......	.....	Black and white square daymark.	
16412 *J 4806.2*	— — Front	21 03 73 39	F. Or	......	.....	Black and white square daymark.	
16412.1 *J 4806.21*	— — Rear, 131 yards 130° from front.	....	F. Or	......	.....	Black and white square daymark.	
16420 *J 4806.4*	— N. of Ft. Henriette, front.	20 57 73 41	F. R	......	4	....	
16420.1 *J 4806.41*	— — Rear, about 50 yards 76° from front.	....	F. R	......	4	Post, white diamond, black border; 7.	
16430 *J 4806.2*	— S. of Louise Point, front.	20 57 73 40	F. R	......	4	Post, white diamond, black border; 7.	
16430.1 *J 4806.21*	— — Rear, about 50 yards 112° from front.	....	F. R	......	4	Post, white diamond, black border; 15.	
	CAICOS ISLANDS:						
16435 *J 4806.8*	— Providenciales Island, NW. point.	21 49 72 09	Fl. W. .... period 10^s	......	12	....	
16436	— Providenciales, NW. point.	21 52 72 20	Gp. Fl. W. (3) .... period 15^s fl. 0.5^s, ec. 2.0^s fl. 0.5^s, ec. 2.0^s fl. 0.5^s, ec. 9.5^s	......	14	....	
16438 *J 4807*	— Cape Comete, E. Caicos Island.	21 43 71 28	Gp. Fl. W. (2) .... period 20^s	......	15	....	
16440 *J 4808*	— South Caicos Island Cockburn Harbor, on Government Hill.	21 30 71 31	F. W	50 15	9	White building, flat roof; 15.	Visible 180°–90°.
16445	— Long Cay	21 29 71 31	Fl. R. .... period 2.5^s	......	5	....	
16448	— Bush Cay	21 11 71 38	Gp. Fl. W. (2) .... period 10^s fl. 0.5^s, ec. 2.0^s fl. 0.5^s, ec. 7.0^s	......	14	....	

Figure 7-13.—Sample from Light Lists.

inland waterways, is promulgated in Light Lists published by the United States Coast Guard.

HANDLING CHARTS

Correcting, stowing, and keeping an accurate file on charts account for much of a Quartermaster's duty. It could be a full-time job on a ship using many charts.

STOWING CHARTS

Within the portfolio system, charts are arranged and numbered in a geographical sequence which provides for systematic stowage of charts aboard ship. With the exception of Portfolios WA and WP, the 54 portfolios are composed of charts at a scale of 1:2,000,000 and larger. To establish a logical numbering system within the geographical subregions (portfolios), a worldwide skeleton grid framework of coastal charts was laid out at a scale of 1:250,000. This skeleton series is used as basic coverage for the numbering except in areas where a coordinated series at about this scale currently exists. An example of an exception is the coast of Norway where a coordinated series of 1:200,000 coastal charts are in existence. Within each region, the geographical subregions (portfolios) are numbered counterclockwise around the continents, and, within each subregion, the basic (1:250,000 skeleton) series is also numbered counterclockwise around the continents. The skeleton coverage is assigned generally every 20th digit, except that the first 40 numbers in each subregion are reserved for smaller-scale coverage. Charts with scales larger than the skeleton 1:250,000 coverage are assigned one of the 19 numbers following the number assigned to the skeleton sheet within which it falls. Thus, the last three digits of a five-digit numbered chart identify the chart in geographical order within the subregion or portfolio, with many numbers left unused so that charts produced in the future may be placed within this same geographical order.

Arrangements of charts within a portfolio begins with the smaller-scale coverage of charts; that is, all charts at a scale smaller than 1:250,000 covering the portfolio are assigned initially. Therefore, these will be the first chart numbers within a portfolio. (The first 40 numbers, 000-039, are used for this purpose.) The skeleton series (1:250,000) then comes into prominence beginning with the last three digits of a chart numbered 040 and continuing with 060,100, etc., until all coverage within a portfolio area is included. Charts at scales larger than 1:250,000 are then numbered within the skeleton series such as 041, 042, 061, 062, 081, 082, 101, 102, etc. Within this scheme it is readily apparent that chart numbers will not be listed in a strict numerical sense of using all digits. In this way provision is made to include future charts into the scheme without having to establish a suffix to each chart number. In addition to charts produced or reproduced by DMA Hydrographic Center, the National Ocean Survey (formerly USC & GS charts) and foreign charts stocked within the DMA Distribution System are also identified with a number so that all charts fall within the portfolio format.

Charts must be stowed in an orderly manner in the compartments or drawers specially designed for the purpose. They should always be laid flat. It may be necessary to fold some charts, but they must never be rolled. When folding is necessary, try to follow the original folds. Special precautions must be taken to prevent curling at the edges.

It is a good idea to have a list of the charts contained in your portfolios. To make sure you still have all the charts on the list, occasionally check the charts in the portfolios against this list.

CORRECTING CHARTS

Defense Mapping Agency Hydrographic Center publications mentioned thus far are published at more or less widely separated intervals. As a result, provisions must be made for keeping mariners apprised of changes in hydrographic conditions as soon as possible after they occur.

The principal medium for distributing corrections to charts, light lists, and other DMAHC publications is Notice to Mariners. One or more copies are distributed to each naval vessel. Each notice is divided into three sections.

Section I, chart corrections; Section II, light list corrections; and Section III, broadcast warnings.

Supplements to Coast Pilots and looseleaf changes to Sailing Directions, issued periodically, contain all the corrections from Notice to Mariner and other sources received since the issue date of either the publication itself or the previous supplement or change.

Each chart on board will have a chart correction card on file. With the chart correction card system, only the charts in current use in the operating area of your ship must be kept up to date at all times. Corrections are not made to other charts until the charts are needed. If a chart is uncorrected, a notation is made on the card. The entry gives the Notice to Mariners' number and page number. When a chart is corrected, the date and the initials of the person who corrected the chart are entered in the prescribed spaces on the card.

The weekly Notice to Mariners features a new format for presenting corrective information affecting charts, Sailing Directions, and Coast Pilots. In Section I chart corrections are listed by chart number, beginning with the lowest and progressing in sequence through each chart affected. The chart corrections are followed by publication corrections which are also listed in numerical sequence. Since each correction pertains to a single chart or publication, the action specified applies to that particular chart of publication only. Related charts and publications, if any, are listed separately.

Figure 7-14 explains each of the elements of a typical correction.

A correction preceded by (1) a star (★), indicates it is based on original U.S. source information; (2) the letter "T" indicates it is temporary, and; (3) by the letter "P" indicates it is preliminary.

Courses and bearings are given in degrees clockwise from 000° true. Bearings of light sectors are toward the light.

The visibility of lights is usually the distance that a light can be seen in clear weather and is expressed in nautical miles. Visibilities listed are values received from foreign sources. The visibility of lights listed for U.S. Coast Guard lights are expressed as nominal range.

Chart/Publication Correction Record Card

Before changing any chart, you should go through the Chart/Pub Correction Record (DMAHC-8660/9) cards (figure 7-15) and remove those affected by that particular notice. After withdrawing the cards corresponding to the number entered on the chart correction list, you are ready to enter the necessary data on the cards. Prepare a card for each chart/publication, inserting the following information:

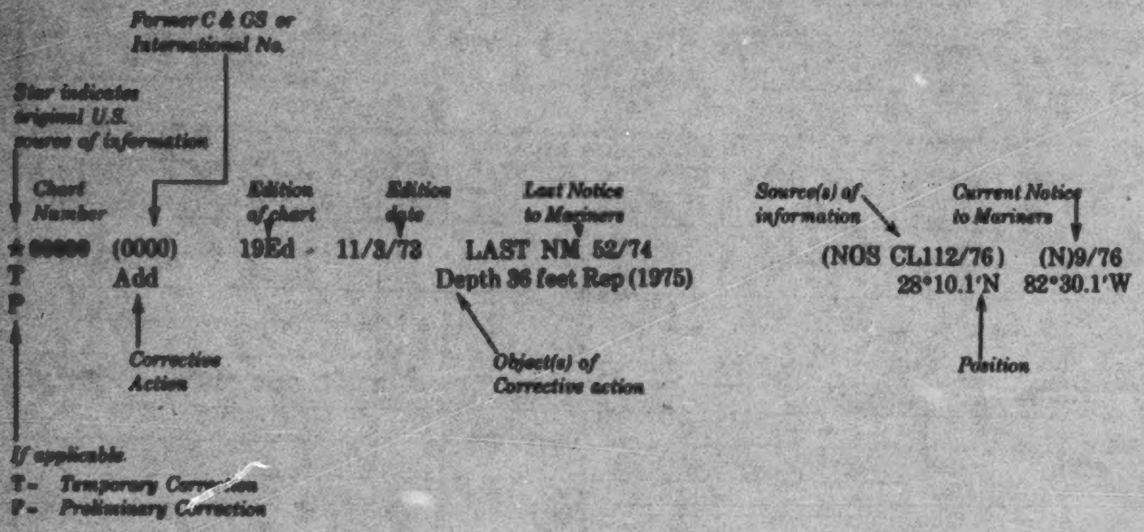
Chart/Publication Number (e.g., 97060)
Portfolio (e.g., A97)
Edition No/Date (e.g., 1/Jan 1945)
Classification (e.g., "U" for Unclassified)

Title ofChart/Publication (If title is too long, use an abbreviated descriptive title.)

NOTE: In correcting charts which have accumulated numerous corrections, it is more practical to make the latest correction first and work backwards, because late corrections may cancel or alter earlier corrections.

Upon receipt of a new chart and/or a new edition, a new card should be made so that the card will show only those corrections (including temporary changes) which have been published since the date to which the chart was corrected by the DMAHC. Temporary changes are not incorporated in new editions of charts and must be carried forward from old editions. Consult NM 13, 26, 39, and 52 for outstanding temporary corrections. At the end of each quarter, the DMAHC will include in the Notice to Mariners a Chart Correction List, for that quarter, containing all effective Notice to Mariners corrections to charts. The list for Navy Notice to Mariners corrections will be published annually. These lists should be checked against the cards to assure that all corrections have been entered.

The card is designed for use in recording all Notice to Mariners corrections affecting charts and publications held on board. With this record, only the charts and publications of the


Former C & GS or International No.
Star indicates original U.S. source of information
Chart Number
Edition of chart
Edition date
Last Notice to Mariners
Source(s) of information
Current Notice to Mariners
★00000 (0000) 19Ed - 11/3/78 LAST NM 52/74
T Add Depth 36 feet Rep (1975)
P
(NOS CL112/76) (N)9/76
28°10.1'N 82°30.1'W
Corrective Action
Object(s) of Corrective action
Position
If applicable
T- Temporary Correction
P- Preliminary Correction

69.35

Figure 7-14.—Typical corrections format.

operating area need to be corrected. Charts and publications not immediately required may be updated as areas of operations change. Holders of nautical material must ensure that a card record is maintained for Notice to Mariners corrections to all charts and publications carried aboard, with actual corrections being made on those charts and publications prior to being used for navigational purposes. When the correction record cards are established for the charts and publications, the following procedures should be followed in maintaining the system.

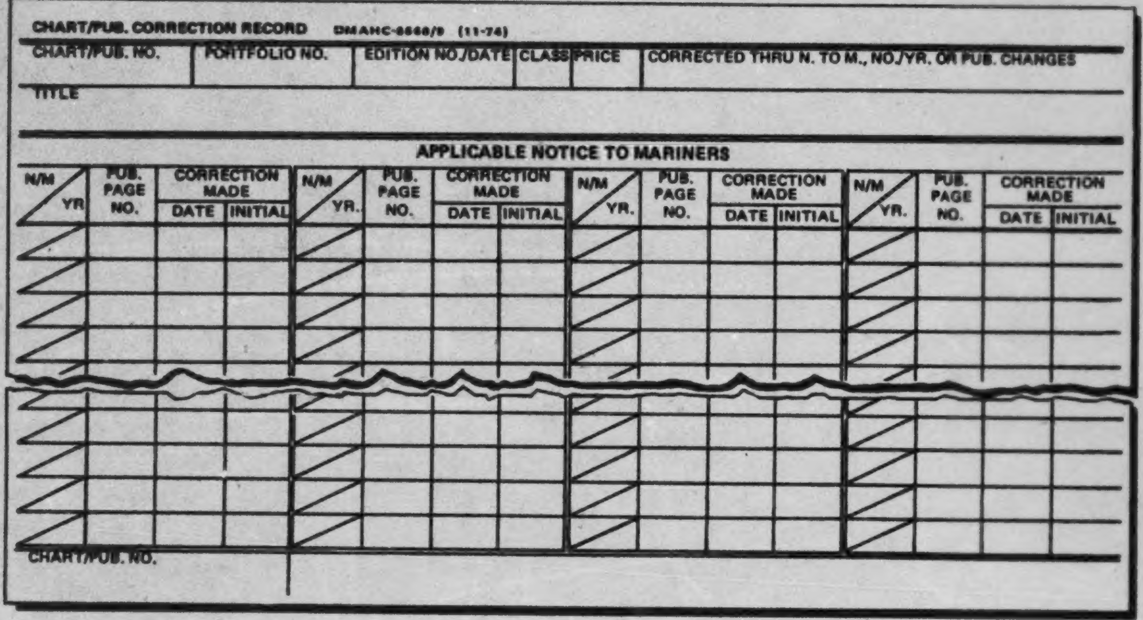
Where corrections have been made aboard ship since the chart was received, the Notice to Mariners number and year should be entered on the card. The chart should also be annotated to indicate that corrections have been made.

After all entries have been made on the cards, the applicable corrections from Notice to Mariners should be plotted on those charts which are in active use. Entries are to be made on the corresponding correction cards to show the date and the person who made the correction. The commanding officer of the ship will determine which charts are to be kept corrected to date. Put a list of those charts in the front of Pub. No. 1-PCL for reference.

Chart Correction Techniques

After a little practice on obsolete charts, corrections to printed information on nautical charts can be made neatly and quickly. These corrections become a permanent part of the chart and may involve the safety of the ship; therefore, they must be made in ink so they will not be accidently erased when cleaning the chart after use. The only instruments necessary to correct charts are several high-quality ballpoint pens or central feed technical fountain pens, a variety of stick or pencil-type erasers, an erasing shield, and a Chart Correction Template 9998.

Frequently, the first step in correcting a chart is to erase that part of the charted information that will be changed. To erase an inked line, rest the chart on a smooth surface. The top of a chart table is well suited for this; but, if an improvised surface is needed, place the



CHART/PUB. CORRECTION RECORD DMAHC-8660/9 (11-74)

CHART/PUB. NO. | PORTFOLIO NO. | EDITION NO./DATE | CLASS | PRICE | CORRECTED THRU N. TO M., NO./YR. OR PUB. CHANGES

TITLE

APPLICABLE NOTICE TO MARINERS

N/M / YR	PUB. PAGE NO.	CORRECTION MADE		N/M / YR.	PUB. PAGE NO.	CORRECTION MADE		N/M / YR.	PUB. PAGE NO.	CORRECTION MADE		N/M / YR.	PUB. PAGE NO.	CORRECTION MADE	
		DATE	INITIAL			DATE	INITIAL			DATE	INITIAL			DATE	INITIAL

CHART/PUB. NO.

69.36

Figure 7-15.—Chart/Pub. Correction Record (DMAHC-8660/9).

areas to be erased over a large surface that is smooth and hard. Erase in a back and forth motion with an abrasive eraser. This will remove most of the ink. To preserve the quality of the paper's surface, remove the remainder of the ink with a nonabrasive eraser. Most typewriter erasers are very abrasive and general erasers are mildly abrasive. A sharp penknife or razor blade used to erase can be a valuable tool in the hands of an experienced draftsman, but poor handling of a knife can quickly ruin a chart. Rubbing an erased surface with an ivory or bone burnishing tool, or even the thumbnail, may improve its inking qualities. The ink from a conventional lettering or drafting pen tends to feather to a degree depending on the condition of the erased surface. Normally, a ballpoint pen with a fine point feathers less and reduces the possibility of ink smears. Another advantage of the ballpoint is the variety of colored inks available. Although black is the principal color used in chart correction work, other colors such as green, purple, magenta, or blue may be occasionally needed.

Corrections in writing should be kept clear of the water, as much as possible, unless the objects referred to are on the water.

When inserting written corrections, care must be taken not to obliterate any of the information already on the chart.

When "notes" are to be inserted (such as cautionary, tidal, etc.) they should be written in a convenient but conspicuous place, where they will not interfere with any other details.

The year and number of every Notice to Mariners from which corrections have been made are to be entered in ink at the lower left-hand corner of the charts, thus: "1968-6, 9, 18." Temporary changes should be made in pencil.

CHARTS UNDER RED LIGHTS

Red has been selected as the preferred color for night lighting. This red color effect may be attained by the use of red bulbs, red shields or filters, or red goggles. The use of red lights seriously affects the legibility of charts such as the buff, orange, and red colors are all invisible under red lighting. The DMAHC has met this situation through the use on charts of gray, magenta, purple, and blue. These colors appear as different shades, not as different colors, under the red light. Caution should be exercised in using the old charts under red light. If there are any vital features shown on the charts in red, orange, and yellow colors, it will be necessary to redraw them in some color that will show, such as blue, green, brown, or purple. The use of red ink or red pencil should be avoided.

ORDERING CHARTS

Ships of the Pacific Fleet are requested to address their requisitions for charts to the DMA Depot, Clearfield, Utah 84016. Ships of the Atlantic Fleet send their requisitions to the DMA Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120. If an emergency arises, as when a ship receives orders on short notice, address the requisition to the nearest DMAHC Office.

All requests for complete portfolios and individual charts should be submitted by the Navigator, in accordance with the current DMA INST 8620.1, on DD Form 1149 (figure 7-16) to the supporting DMA Depot. All requests must bear an appropriate issue priority designator, assigned in accordance with the current OPNAVINST 4614.1, and must be signed by the commanding officer or an authorized representative.

Assignment of Priorities to Requisitions

Naval activities and units submitting requests for charts, maps, and publications must assign priorities in accordance with OPNAVINST 4614.1. Requests for charts and publications which contain unrealistic priorities interfere with the service capabilities of the DMA Distribution System. Basically, the assignment of a priority to a requisition is dependent upon the status of the unit which within the instruction is referred to as the "force activity designator" (FAD), and the urgency (or degree) of need at the time a requisition is prepared. These terms are illustrated and described as follows:

Force Activity Designator	Urgency of Need		
	A	B	C
I - Combat	1	4	11
II - Positioned	2	5	12
III - Ready	3	6	13
IV - Reserve/Support	7	9	14
V - Other	8	10	15

The "urgency of need" is defined as follows:

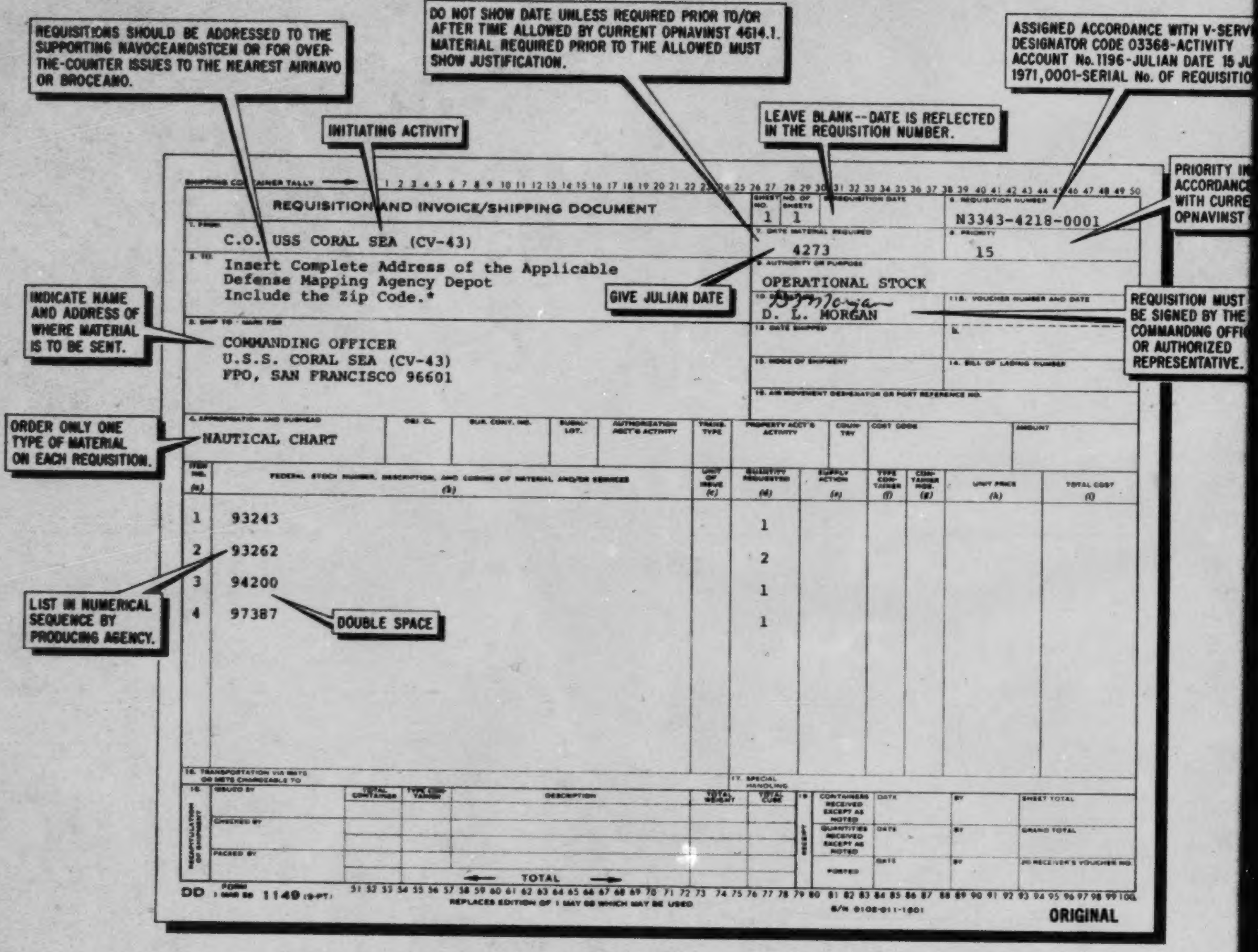
A–An emergency requirement for weapons, equipment, or material without which the ship cannot perform its mission or work stoppages are immediate.

B–Items required for immediate use, the lack of which will impair the operational capability of the ship, or without which the ship can operate only temporarily or with lessened efficiency and effectiveness.

C–Material required immediately to repair or replace collateral or administrative system equipment not essential to the effectiveness of the ship, or required to meet a scheduled deployment, or required on a more urgent basis than routine stock replenishment, or required to replenish stocks during deployment.

D–Material required for initial outfitting and filling of allowances, and other routine replenishment and filling of allowance list requirements.

It is simple to obtain your force activity designator and to determine your urgency (degree) of need. By definition of purpose, most requirements fit FAD IV or V and category C for degree of need.



REQUISITIONS SHOULD BE ADDRESSED TO THE SUPPORTING NAVOCEANDISTCEN OR FOR OVER-THE-COUNTER ISSUES TO THE NEAREST AIRNAVO OR BROCEANO.

DO NOT SHOW DATE UNLESS REQUIRED PRIOR TO/OR AFTER TIME ALLOWED BY CURRENT OPNAVINST 4614.1. MATERIAL REQUIRED PRIOR TO THE ALLOWED MUST SHOW JUSTIFICATION.

ASSIGNED ACCORDANCE WITH V-SERV
DESIGNATOR CODE 03368-ACTIVITY
ACCOUNT No. 1196-JULIAN DATE 15 JU
1971, 0001-SERIAL No. OF REQUISITIO

INITIATING ACTIVITY

LEAVE BLANK--DATE IS REFLECTED IN THE REQUISITION NUMBER.

PRIORITY IN
ACCORDANCE
WITH CURRE
OPNAVINST

INDICATE NAME AND ADDRESS OF WHERE MATERIAL IS TO BE SENT.

GIVE JULIAN DATE

REQUISITION MUST
BE SIGNED BY THE
COMMANDING OFFIC
OR AUTHORIZED
REPRESENTATIVE.

ORDER ONLY ONE TYPE OF MATERIAL ON EACH REQUISITION.

LIST IN NUMERICAL SEQUENCE BY PRODUCING AGENCY.

DOUBLE SPACE

SHIPPING CONTAINER TALLY → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO. 1 NO. OF SHEETS 1

5. REQUISITION DATE

6. REQUISITION NUMBER: N3343-4218-0001

1. FROM: C.O. USS CORAL SEA (CV-43)

7. DATE MATERIAL REQUIRED: 4273

8. PRIORITY: 15

2. TO:
Insert Complete Address of the Applicable
Defense Mapping Agency Depot
Include the Zip Code.*

9. AUTHORITY OR PURPOSE: OPERATIONAL STOCK

10. SIGNATURE: D L Morgan
D. L. MORGAN

11a. VOUCHER NUMBER AND DATE

b.

3. SHIP TO - MARK FOR:
COMMANDING OFFICER
U.S.S. CORAL SEA (CV-43)
FPO, SAN FRANCISCO 96601

12. DATE SHIPPED

13. MODE OF SHIPMENT

14. BILL OF LADING NUMBER

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.

4. APPROPRIATION AND SUBHEAD	OBJ. CL.	BUR. CONT. NO.	SUBAL-LOT.	AUTHORIZATION ACCT'G ACTIVITY	TRANS. TYPE	PROPERTY ACCT'G ACTIVITY	COUNTRY	COST CODE	AMOUNT
NAUTICAL CHART									

ITEM NO. (a)	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIAL AND/OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CONTAINER (f)	CONTAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)
1	93243		1					
2	93262		2					
3	94200		1					
4	97387		1					

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

RECAPITULATION OF SHIPMENT		TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE	19. RECEIPT			
18.	ISSUED BY						CONTAINERS RECEIVED EXCEPT AS NOTED	DATE	BY	SHEET TOTAL
	CHECKED BY						QUANTITIES RECEIVED EXCEPT AS NOTED	DATE	BY	GRAND TOTAL
	PACKED BY						POSTED	DATE	BY	20. RECEIVER'S VOUCHER NO.
			← TOTAL →							

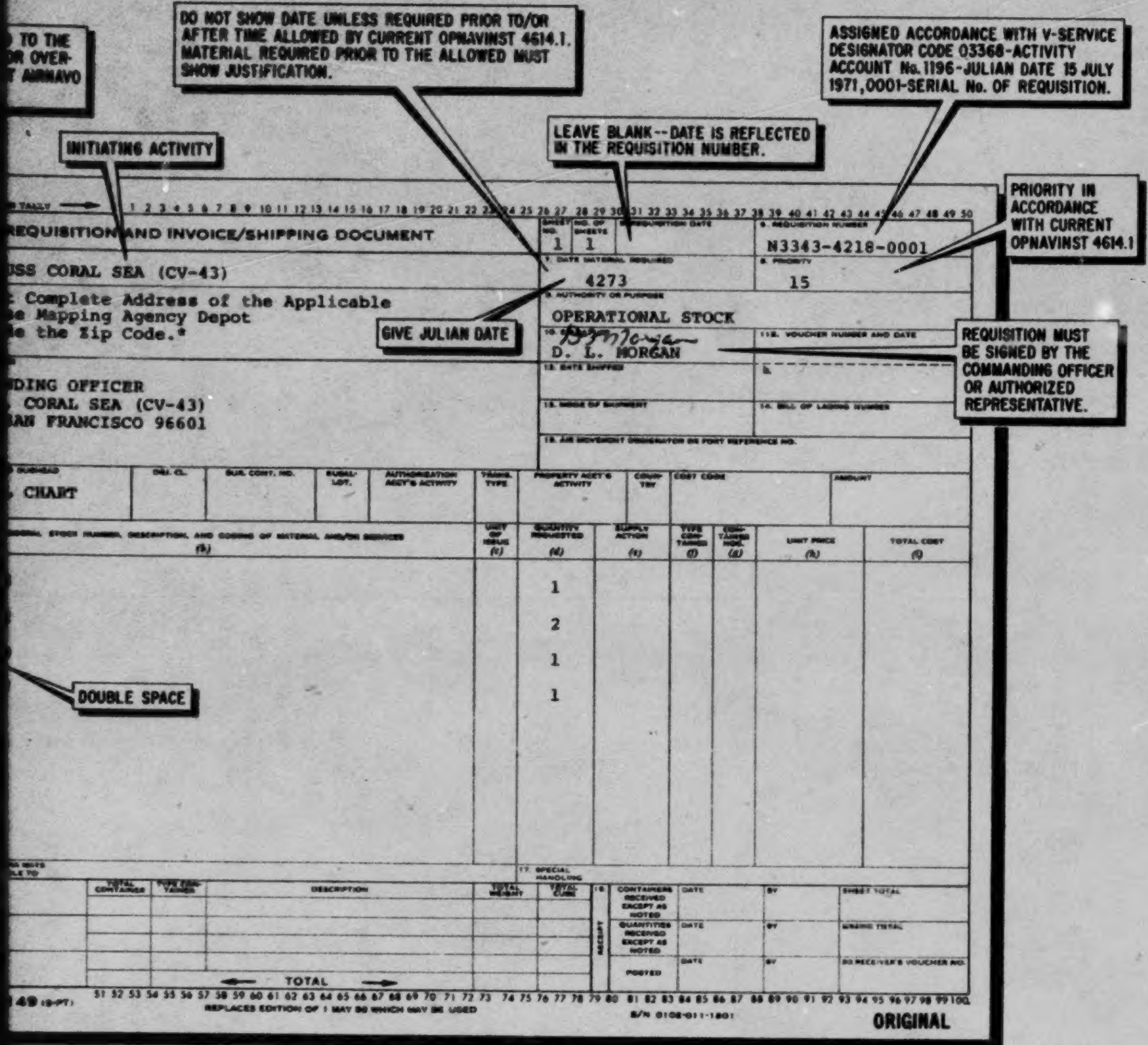
DD FORM 1 MAR 58 1149 (9-PT) 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

REPLACES EDITION OF 1 MAY 55 WHICH MAY BE USED

S/N 0102-011-1801

ORIGINAL

Figure 7-16.—DD Form 1149.



D TO THE
OR OVER-
T AIRNAVO

DO NOT SHOW DATE UNLESS REQUIRED PRIOR TO/OR AFTER TIME ALLOWED BY CURRENT OPNAVINST 4614.1. MATERIAL REQUIRED PRIOR TO THE ALLOWED MUST SHOW JUSTIFICATION.

ASSIGNED ACCORDANCE WITH V-SERVICE DESIGNATOR CODE 03368-ACTIVITY ACCOUNT No. 1196-JULIAN DATE 15 JULY 1971, 0001-SERIAL No. OF REQUISITION.

INITIATING ACTIVITY

LEAVE BLANK--DATE IS REFLECTED IN THE REQUISITION NUMBER.

PRIORITY IN ACCORDANCE WITH CURRENT OPNAVINST 4614.1

TALLY → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

SHEET NO. 1	NO. OF SHEETS 1

REQUISITION DATE

6. REQUISITION NUMBER
N3343-4218-0001

USS CORAL SEA (CV-43)

7. DATE MATERIAL REQUIRED
4273

8. PRIORITY
15

Complete Address of the Applicable
e Mapping Agency Depot
e the Zip Code.*

GIVE JULIAN DATE

9. AUTHORITY OR PURPOSE
OPERATIONAL STOCK

10. SIGNATURE
D L Morgan
D. L. MORGAN

11B. VOUCHER NUMBER AND DATE

REQUISITION MUST BE SIGNED BY THE COMMANDING OFFICER OR AUTHORIZED REPRESENTATIVE.

DING OFFICER
CORAL SEA (CV-43)
AN FRANCISCO 96601

12. DATE SHIPPED

13. MODE OF SHIPMENT

14. BILL OF LADING NUMBER

15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.

SUBHEAD	OBJ. CL.	SUB. CONT. NO.	SUBALLOT.	AUTHORIZATION ACCT'G ACTIVITY	TRANS. TYPE	PROPERTY ACCT'G ACTIVITY	COUNTRY	COST CODE	AMOUNT
CHART									

STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIAL AND/OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CONTAINER (f)	CONTAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)
		1					
		2					
		1					
		1					

DOUBLE SPACE

17. SPECIAL HANDLING

TOTAL CONTAINERS	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
		← TOTAL →		

18. RECEIPT			
CONTAINERS RECEIVED EXCEPT AS NOTED	DATE	BY	SHEET TOTAL
QUANTITIES RECEIVED EXCEPT AS NOTED	DATE	BY	GRAND TOTAL
POSTED	DATE	BY	20. RECEIVER'S VOUCHER NO.

51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

49 (9-77) REPLACES EDITION OF 1 MAY 50 WHICH MAY BE USED S/N 0102-011-1801

ORIGINAL

Figure 7-16.—DD Form 1149.

43.3

A priority 9 or 15 should cover most requirements for navigational charts or publications. The table below indicates the maximum delivery time associated with the range or priorities:

Priority	Conus (Days)	Overseas (Days)
01-03	5	7
04-08	8	15
09-15	20	45

NOTE: These are maximum delivery times established for supply support. Routine map/chart requests, even priority 15, are normally filled (delivered to the customer) in about 10 to 15 days since most requisitions do not involve bulk shipments and are filled via the U.S. Postal System. Bulk shipments may take somewhat longer to deliver, subject to transportation limitations.

Do not order from a DMA Depot any publication not issued by that office. Copies of the Nautical Almanac, Air Almanac, and American Ephermeris and Nautical Almanac, for instance, are ordered from the Naval Observatory. The Watch Officer's Guide, Hobbs Marine Navigation I and II, Knight's Modern Seamanship, Dutton's Navigation and Piloting, and Mixter's Primer of Navigation are ordered from the Library Division of the Bureau of Naval Personnel instead of from the DMA.

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1. Only persons with the necessary security clearance and a definite need to know should be granted access to the information.
2. When classified material is not under the direct observation of an authorized person, it must be locked up or given equivalent protection.
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4. Money, jewels, or other valuables must never be stowed in containers used for stowing classified material.
5. Combinations (or keys) to safes or locks must be accessible only to persons whose official duties require access to the material in the containers.

CHAPTER 8

TIME AND TIMEPIECES

The navigator steps out on the bridge wing and takes a sight on the star Vega. After applying various corrections to the sextant altitude, he determines the altitude of Vega from his position at the instant of observation. From tables he extracts the altitude of Vega from a previously selected assumed position (AP) at the instant he took his sight. He then finds (again, from tables) the azimuth of Vega from the AP. The difference between the altitude from his actual position and the altitude from the assumed position enables him to calculate how far away he was from the AP at the instant of observation. He measures this distance along the azimuth line and thus establishes a line of position.

The foregoing general outline tells how a line of position is determined by celestial navigation. The reason it is inserted here prematurely is to impress upon you the importance of the time element in navigation. Suppose the navigator's observation is inaccurate by 1 minute. Although 1 minute of time isn't very long, it can make considerable difference in navigation. Instead of the actual observation time, suppose the altitude is worked out for 1 minute earlier or later, which could produce an error of as much as 15 miles in the resulting line of position. Regardless of your latitude, a 1-minute time error produces a 15-arc minute error in longitude. On the Equator, 1 minute of longitude equals 1 nautical mile.

You know, of course, that the motion of the Sun and the stars around the Earth is only apparent—an illusion created by the rotation of the Earth itself. Nevertheless, in the discussion of time which follows, it is simpler to consider the heavenly bodies as moving around the Earth.

TIME AND ARC

Ordinarily, we use solar time, which is measured by the motion of the Sun around the Earth. If you are standing on the main deck aft of a ship headed due north and the Sun passes your given meridian (your longitude), it is noon where you are at that time; but, if the ship were headed due east, noon would occur on the forecastle before it would occur at your after location.

Every celestial observation is timed according to the time at the Greenwich meridian. Usually time is determined by means of the chronometer, which is set to Greenwich time. In order to clarify the relationship between time and arc, let's say that it is exactly noon where you are, you know your longitude, and you want to find what time it is in Greenwich.

Because of the Earth's rotation the Sun appears to make a complete 360° revolution around the Earth every 24 hours (h). When the Sun is on a particular meridian, it is noon along that meridian. In other words, when the Sun is on the Greenwich meridian (0°), it is noon by Greenwich time. To make the explanation simpler, let's say you're in 90°W longitude. It's noon where you are, so the Sun also is in 90°W. That is, since leaving Greenwich, the Sun traveled through 90° of arc. Because it was 1200 Greenwich time when the Sun was at 0°, the time at Greenwich now must be 1200 plus the time required for the Sun to travel through 90° of arc.

The foregoing explanation provides all the elements of a problem for converting arc to time. If you know that it takes 24h for the Sun to travel 360°, it should be a cinch to find how long is required for it to go 90°. Thus, if it travels 360° in 24h, it must go 15° in 1h. If it transits 15° in 1h, it must go 1° in 4 minutes (m). Then, to go 90° requires 90 multiplied by 4m, or 360m, which is 6h. Six hours ago it was 1200 Greenwich time. Therefore, the time at Greenwich now must be 1800. You actually have converted 90° of arc to 6h of time. In doing so, you discovered the basic relationship between arc and time. This relationship is stated as 15° of longitude (arc) equals 1 hour of time.

You can also convert time to arc–the reverse of the example just worked. Tables for converting either way are in the Nautical Almanac (see figure 8-1) and in Bowditch.

KINDS OF TIME

Astronomy provides the basis for measuring time which is of paramount importance to the navigator. A day is measured as one rotation of the Earth about its axis. The external reference point determines the type of time considered: solar, sidereal, or lunar. Apparent and mean time are applied in certain problems of navigation. The difference between apparent and mean time is called equation of time.

APPARENT TIME

The Sun, as mentioned earlier, is our most convenient reference point for reckoning time. Time measured by the Sun is solar time. Rotation of the Earth on its axis produces apparent motion of the Sun around it. When we measure time by the apparent motion of the Sun itself, we call it apparent time. If the Sun is directly over the meridian we are on, we say that it is noon, local apparent time. When it is directly over the meridian 180° away from ours, it is midnight, local apparent time.

If the Earth remained stationary in space, all the days reckoned by apparent time would be the same length. But the Earth travels in an elliptical orbit inclined to the equatorial plane around the Sun, and its speed along its orbit varies with its position in its orbit. Consequently, the time required for a complete rotation of the Earth on its axis, relative to the Sun, varies according to position of the Earth in its orbit. The length of a day, therefore, reckoned by a complete rotation of the Earth with regard to the Sun, also varies.

MEAN TIME

Instead of each day having exactly 24 hours, it would be rather confusing if some days had more and some fewer hours to conform to the irregularities of the Earth's revolution. To preserve the obvious advantages of solar time, yet eliminate these irregularities, mean solar time is used. It is calculated from the motion around the Earth of an imaginary mean sun, which always makes the 360° trip in exactly 24 hours. When it is noon by local mean time (LMT), the mean sun, in lieu of the true sun, is exactly over your meridian.

Four times a year the positions of the mean and the true Sun coincide. In other words, on those four occasions there is no difference between apparent and mean time. Otherwise, there always is a difference, called the equation of time, which is listed in the *Nautical Almanac* for every 12 hours of Greenwich mean time (GMT) of the Sun on any date. The equation of time reaches a maximum of nearly 16-½ minutes.

SOLAR, SIDEREAL, AND LUNAR TIME

Solar time, we learned, is calculated from the motion of the Sun around the Earth. Solar time is the principal time used in navigation.

Sidereal time, calculated from the motion of the stars around the Earth, is used in the procedure for identifying heavenly bodies (described later). For the present, all you need to know about sidereal time is that it is measured by the motion around the Earth of the first point of Aries. A sidereal day is about 4 minutes shorter than a mean solar day, and there are 366-¼ sidereal days in 365-¼ mean solar days.

A lunar day is the elapsed time between two consecutive transits of the moon over an observer's meridian; it is about 50 minutes longer than a mean solar day. Moon data is used in some navigation problems and in tide analysis.

CONVERSION OF ARC TO TIME

0°–59°		60°–119°		120°–179°		180°–239°		240°–299°		300°–359°			0′.00	0′.25	0′.50	0′.75
°	h m	°	h m	°	h m	°	h m	°	h m	°	h m	′	m s	m s	m s	m s
0	0 00	60	4 00	120	8 00	180	12 00	240	16 00	300	20 00	0	0 00	0 01	0 02	0 03
1	0 04	61	4 04	121	8 04	181	12 04	241	16 04	301	20 04	1	0 04	0 05	0 06	0 07
2	0 08	62	4 08	122	8 08	182	12 08	242	16 08	302	20 08	2	0 08	0 09	0 10	0 11
3	0 12	63	4 12	123	8 12	183	12 12	243	16 12	303	20 12	3	0 12	0 13	0 14	0 15
4	0 16	64	4 16	124	8 16	184	12 16	244	16 16	304	20 16	4	0 16	0 17	0 18	0 19
5	0 20	65	4 20	125	8 20	185	12 20	245	16 20	305	20 20	5	0 20	0 21	0 22	0 23
6	0 24	66	4 24	126	8 24	186	12 24	246	16 24	306	20 24	6	0 24	0 25	0 26	0 27
7	0 28	67	4 28	127	8 28	187	12 28	247	16 28	307	20 28	7	0 28	0 29	0 30	0 31
8	0 32	68	4 32	128	8 32	188	12 32	248	16 32	308	20 32	8	0 32	0 33	0 34	0 35
9	0 36	69	4 36	129	8 36	189	12 36	249	16 36	309	20 36	9	0 36	0 37	0 38	0 39
10	0 40	70	4 40	130	8 40	190	12 40	250	16 40	310	20 40	10	0 40	0 41	0 42	0 43
11	0 44	71	4 44	131	8 44	191	12 44	251	16 44	311	20 44	11	0 44	0 45	0 46	0 47
12	0 48	72	4 48	132	8 48	192	12 48	252	16 48	312	20 48	12	0 48	0 49	0 50	0 51
13	0 52	73	4 52	133	8 52	193	12 52	253	16 52	313	20 52	13	0 52	0 53	0 54	0 55
14	0 56	74	4 56	134	8 56	194	12 56	254	16 56	314	20 56	14	0 56	0 57	0 58	0 59
15	1 00	75	5 00	135	9 00	195	13 00	255	17 00	315	21 00	15	1 00	1 01	1 02	1 03
16	1 04	76	5 04	136	9 04	196	13 04	256	17 04	316	21 04	16	1 04	1 05	1 06	1 07
17	1 08	77	5 08	137	9 08	197	13 08	257	17 08	317	21 08	17	1 08	1 09	1 10	1 11
18	1 12	78	5 12	138	9 12	198	13 12	258	17 12	318	21 12	18	1 12	1 13	1 14	1 15
19	1 16	79	5 16	139	9 16	199	13 16	259	17 16	319	21 16	19	1 16	1 17	1 18	1 19
20	1 20	80	5 20	140	9 20	200	13 20	260	17 20	320	21 20	20	1 20	1 21	1 22	1 23
21	1 24	81	5 24	141	9 24	201	13 24	261	17 24	321	21 24	21	1 24	1 25	1 26	1 27
22	1 28	82	5 28	142	9 28	202	13 28	262	17 28	322	21 28	22	1 28	1 29	1 30	1 31
23	1 32	83	5 32	143	9 32	203	13 32	263	17 32	323	21 32	23	1 32	1 33	1 34	1 35
24	1 36	84	5 36	144	9 36	204	13 36	264	17 36	324	21 36	24	1 36	1 37	1 38	1 39
25	1 40	85	5 40	145	9 40	205	13 40	265	17 40	325	21 40	25	1 40	1 41	1 42	1 43
26	1 44	86	5 44	146	9 44	206	13 44	266	17 44	326	21 44	26	1 44	1 45	1 46	1 47
27	1 48	87	5 48	147	9 48	207	13 48	267	17 48	327	21 48	27	1 48	1 49	1 50	1 51
28	1 52	88	5 52	148	9 52	208	13 52	268	17 52	328	21 52	28	1 52	1 53	1 54	1 55
29	1 56	89	5 56	149	9 56	209	13 56	269	17 56	329	21 56	29	1 56	1 57	1 58	1 59
30	2 00	90	6 00	150	10 00	210	14 00	270	18 00	330	22 00	30	2 00	2 01	2 02	2 03
31	2 04	91	6 04	151	10 04	211	14 04	271	18 04	331	22 04	31	2 04	2 05	2 06	2 07
32	2 08	92	6 08	152	10 08	212	14 08	272	18 08	332	22 08	32	2 08	2 09	2 10	2 11
33	2 12	93	6 12	153	10 12	213	14 12	273	18 12	333	22 12	33	2 12	2 13	2 14	2 15
34	2 16	94	6 16	154	10 16	214	14 16	274	18 16	334	22 16	34	2 16	2 17	2 18	2 19
35	2 20	95	6 20	155	10 20	215	14 20	275	18 20	335	22 20	35	2 20	2 21	2 22	2 23
36	2 24	96	6 24	156	10 24	216	14 24	276	18 24	336	22 24	36	2 24	2 25	2 26	2 27
37	2 28	97	6 28	157	10 28	217	14 28	277	18 28	337	22 28	37	2 28	2 29	2 30	2 31
38	2 32	98	6 32	158	10 32	218	14 32	278	18 32	338	22 32	38	2 32	2 33	2 34	2 35
39	2 36	99	6 36	159	10 36	219	14 36	279	18 36	339	22 36	39	2 36	2 37	2 38	2 39
40	2 40	100	6 40	160	10 40	220	14 40	280	18 40	340	22 40	40	2 40	2 41	2 [illegible]	2 43
41	2 44	101	6 44	161	10 44	221	14 44	281	18 44	341	22 44	41	2 44	2 45	2 46	2 47
42	2 48	102	6 48	162	10 48	222	14 48	282	18 48	342	22 48	42	2 48	2 49	2 50	2 51
43	2 52	103	6 52	163	10 52	223	14 52	283	18 52	343	22 52	43	2 52	2 53	2 54	2 55
44	2 56	104	6 56	164	10 56	224	14 56	284	18 56	344	22 56	44	2 56	2 57	2 58	2 59
45	3 00	105	7 00	165	11 00	225	15 00	285	19 00	345	23 00	45	3 00	3 01	3 02	3 03
46	3 04	106	7 04	166	11 04	226	15 04	286	19 04	346	23 04	46	3 04	3 05	3 06	3 07
47	3 08	107	7 08	167	11 08	227	15 08	287	19 08	347	23 08	47	3 08	3 09	3 10	3 11
48	3 12	108	7 12	168	11 12	228	15 12	288	19 12	348	23 12	48	3 12	3 13	3 14	3 15
49	3 16	109	7 16	169	11 16	229	15 16	289	19 16	349	23 16	49	3 16	3 17	3 18	3 19
50	3 20	110	7 20	170	11 20	230	15 20	290	19 20	350	23 20	50	3 20	3 21	3 22	3 23
51	3 24	111	7 24	171	11 24	231	15 24	291	19 24	351	23 24	51	3 24	3 25	3 26	3 27
52	3 28	112	7 28	172	11 28	232	15 28	292	19 28	352	23 28	52	3 28	3 29	3 30	3 31
53	3 32	113	7 32	173	11 32	233	15 32	293	19 32	353	23 32	53	3 32	3 33	3 34	3 35
54	3 36	114	7 36	174	11 36	234	15 36	294	19 36	354	23 36	54	3 36	3 37	3 38	3 39
55	3 40	115	7 40	175	11 40	235	15 40	295	19 40	355	23 40	55	3 40	3 41	3 42	3 43
56	3 44	116	7 44	176	11 44	236	15 44	296	19 44	356	23 44	56	3 44	3 45	3 46	3 47
57	3 48	117	7 48	177	11 48	237	15 48	297	19 48	357	23 48	57	3 48	3 49	3 50	3 51
58	3 52	118	7 52	178	11 52	238	15 52	298	19 52	358	23 52	58	3 52	3 53	3 54	3 55
59	3 56	119	7 56	179	11 56	239	15 56	299	19 56	359	23 56	59	3 56	3 57	3 58	3 59

The above table is for converting expressions in arc to their equivalent in time ; its main use in this Almanac is for the conversion of longitude for application to L.M.T. (*added if west, subtracted if east*) to give G.M.T. or vice versa, particularly in the case of sunrise, sunset, etc.

Figure 8-1.—Conversion of arc to time table. 69.150

ZONE (STANDARD) TIME

We have seen that local mean time on the forecastle can be different from local mean time on the main deck aft. In other words, local mean time always differs in different longitudes. In New York City, for example, a difference of about 9s LMT occurs between one end of Forty-Second Street and the other end.

You can understand, now, how a general foulup would result if everyone set his watch on his own LMT. He would have to change it every time he went a few blocks on a street running east and west. To eliminate this difficulty, standard time zones have been established, within which all clocks are set to the same time. A difference of 1 hour takes place between one time zone and the next. Because 1h is 15°, you can see that each time zone comprises 15° of longitude.

The standard time zones begin at the Greenwich meridian (0°). Every meridian east and west of Greenwich that is a multiple of 15° (15°, 30°, 45°, 60°, 75°, and so on) is a standard time meridian. Each standard time meridian is at the center of its time zone, and the zone extends 7°30′ (half of 15°) on either side of the meridian. Certain standard time zones ashore vary somewhat from this procedure to give adjacent populated areas the same time and for other reasons of convenience.

Local mean time along each standard time meridian is zone (standard) time for the entire time zone. Zone time in navigation is abbreviated ZT.

Daylight saving time is simple zone time set ahead 1 hour (sometimes 2 hours) to extend the time of daylight in the evening. Daylight saving time is ignored in navigation.

ZONE TIME AND GMT(UT)

If GMT or universal time (UT) is the time at the Greenwich meridian, measured by the mean Sun, and the Greenwich meridian is the standard time meridian for the time zone, it follows that zone time anywhere in the zone is the same as GMT(UT). Most of the information in navigational tables relates to GMT(UT): hence, you must know how to convert the time in any zone to GMT(UT).

The solar day contains 24h, and each time zone represents 1h, so there must be 24 zones. Beginning with the (Greenwich) zone, time zones run east and west from zone 1 to zone 12. (See figure 8-2.) Zones east of Greenwich are minus; those west of Greenwich are plus zones. (Note that +12 and -12 time zones each include only 7-½° of longitude.) In other words, in zones east of Greenwich, you must subtract the zone number from the zone time to find Greenwich time. In zones west of Greenwich, you must add the two. The zone time at Greenwich is GMT(UT); consequently, the zone number tells you the difference in hours between your zone time and GMT(UT).

Standard time zones are also designated by letters. You can find the equivalent letter designated from the numbered zone by referring to figure 8-2.

Because there is a standard time meridian for every 15° of longitude, you divide your longitude by 15° to find which zone you are in. Then, to find GMT, you merely apply the zone description (ZD) according to its sign.

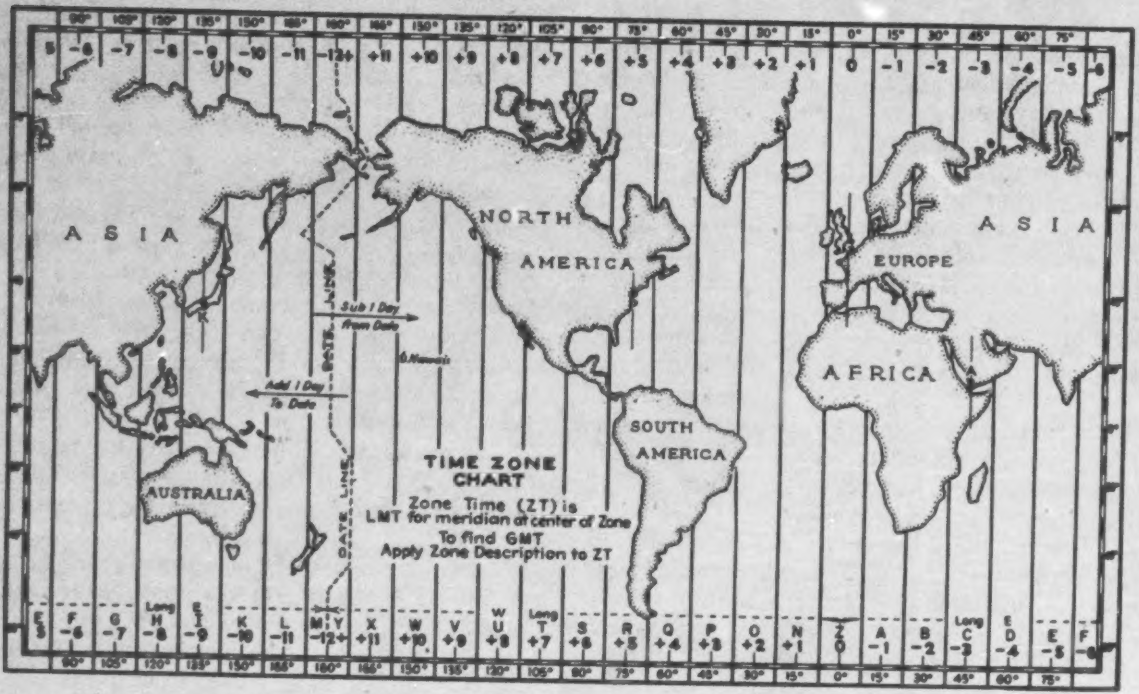
To illustrate, assume that you are in longitude 105°E, ZT is 16h 23m 14s, and you want to find GMT. Dividing 105 by 15 yields 7, which means you are in time zone 7. You are in east longitude, so the sign is minus. Therefore, your ZD is -7h. The minus sign means that you subtract ZD from ZT to find GMT. Thus:

ZT	16h	23m	14s
ZD	-7h		
GMT	9h	23m	14s

Or, suppose you're in longitude 75°W, ZT is 7h 13m 57s, and you want to find GMT. Divide 75 by 15 and your answer is 5. Therefore, you are in zone 5, and it must be plus 5h because your longitude is west. Consequently:

ZT	7h	13m	57s
ZD	+5h		
GMT	12h	13m	57s

In both examples, your longitude coincided with a standard time meridian which simplified the solution somewhat. If you are not located


ASIA
NORTH AMERICA
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTRALIA
DATE LINE
Sub 1 Day from Date
Add 1 Day To Date
Hawaii
TIME ZONE CHART
Zone Time (ZT) is LMT for meridian at center of Zone
To find GMT Apply Zone Description to ZT

13.76(69)

Figure 8-2.—Standard time zones.

on one of these meridians, you can figure out which zone you're in by dividing your longitude by 15 and observing the size of the remainder. You must bear in mind that each standard time meridian is at the center of its time zone, and the zone extends 7°30′ on either side of the meridian. For example, say your longitude is 142°41′W, and you want to know ZD. Dividing 142°41′ by 15, you have 9, with 7°41′ left over. But 7°41′ is more than 7°30′, so you must be in the next zone beyond 9, meaning zone 10.

TIME AND DATE

In the first diagram in figure 8-3, the mean Sun is over the Greenwich meridian, meaning that it is noon, 1 May, GMT(UT). Because it is noon, GMT(UT), it must be 12 hours later (midnight) at the 180th meridian on the other side of the Earth. In other words, the Sun is just starting its 24-hour cruise; it is the same day all the way around the Earth, but a new day is about to begin at the 180th meridian.

As the Sun moves westward, it takes noon along with it, so to speak, and midnight moves along concurrently into east longitude. In the second diagram the Sun has brought noon to 90°W longitude. For the Sun to travel 90° requires 6 hours, so it is 6 hours past noon, or 18h 0m 0s GMT(UT). Midnight has moved to 90°E longitude.

A new day starts as midnight leaves 180°. Thus, between 180° and 90°E, it is the next day, 2 May, while it still is 1 May from 90°E westward to 180°.

Looking at the third diagram, you see that the Sun has brought noon to the 180th meridian, and it is midnight in Greenwich. It now is 2 May from 180° to 0° longitude in the eastern half of the Earth, but still 1 May from 0° to 180° in the western half.

In the last diagram, noon has reached 90°E, and midnight has traveled 6h past Greenwich to 90°W. It is 2 May over three-quarters of the Earth from 180° around to 90°W, but still 1 May over the quarter between 90°W and 180°. On 2 May, GMT is 6h 0m 0s.

The date changes at the 180th meridian in all of the diagrams except the first one. Going west, it becomes the next day at 180°; going east, it becomes the day before.

When you refer to GMT(UT) in the Nautical Almanac, you must know what the date is at Greenwich. Frequently the date there differs from what it is in your longitude. Assume that on 1 May you are in longitude 176°41′ W and ZT is 16h 0m 0s. Divide 176° by 15. The nearest whole number is 12, the ZD. Longitude is west; therefore, ZD is +12h. Adding ZD to ZT, we obtain the following data:

ZT	16h	0m	0s	(1 May)
ZD	+12h			
GMT	28h	0m	0s	(1 May)

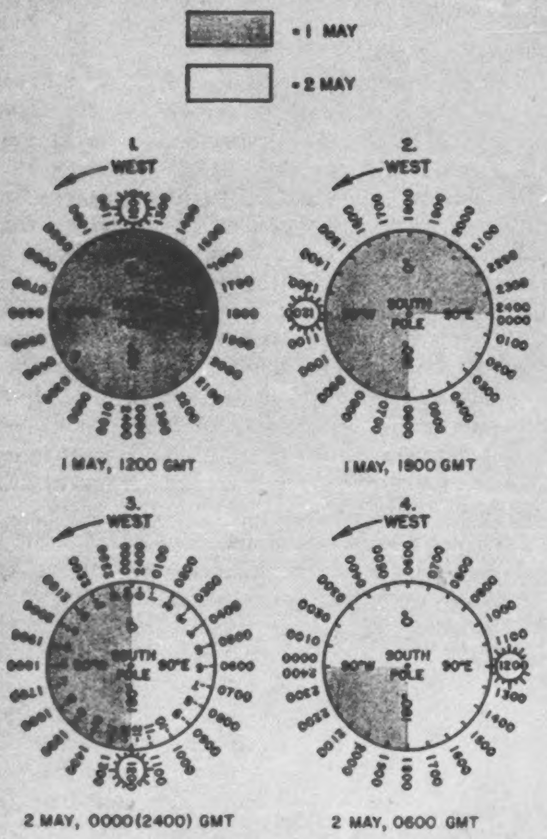
What have we here, 28 o'clock? Time 2800 on 1 May is the same as 0400 on 2 May. Therefore, GMT(UT) is 4h 0m 0s on 2 May.

Suppose that, at the same ZT, you were in longitude 176°41 ′E on the other side of 180, where it is 2 May. In this example, ZD is -12 but GMT(UT) comes out the same; the date where you are is the same as the date at Greenwich. In the former problem, it already has become a day later at Greenwich.

ZT	16h	0m	0s	(2 May)
ZD	-12h			
GMT	4h	0m	0s	(2 May)

Here is a problem with a new twist: Suppose you're in longitude 47° 53 ′E, ZT is 2h 0m 0s, and the date is 2 May. The ZD is -3h. (You should know why by now.) How can you subtract 3 from 2h 0m 0s? Time 0200 on 2 May is the same as 2600 on 1 May. The figuring goes like this:

ZT	26h	(1 May)
ZD	-3h	
GMT	23h	(1 May)



69.37

Figure 8-3.—Date change over the Earth.

ZONE AND LOCAL MEAN TIME

Zone time is a matter of convenience only. It was established to keep all clocks in a specific area on the same time. The actual time where you are is the local mean time, which changes continually as the Sun moves. Local mean time also changes as you change your longitude.

If you are located on one of the standard time meridians, then zone time and local mean time are the same. Otherwise, you must calculate local mean time according to the difference in longitude between your meridian and the closest standard time meridian. You subtract your longitude from the longitude of the meridian. This result is in degrees, minutes, and seconds of arc, which you convert to time and apply to the zone time.

Suppose you are in longitude 142°41′ W and ZT is 06h 21m 09s. Divide 142°41′ by 15, and you find that you are in zone +10. Your standard time meridian must be 150°W. Write that down as 149°60′W so it will be easier to subtract your longitude.

Longitude time meridian . . .	149°60′W
Longitude your meridian . . .	142°41′W
Longitude difference	7° 19′

Change 7°19′ to time, and you get 0h 29m 16s. This change means that LMT at your meridian differs from ZT by 0h 29m 16s. Whether your time is later or earlier than the time at 150°W depends on whether you are east or west of that meridian. You are in west longitude, which is measured west from 0° to 180°, so 150°W must be farther west than 142°41′W. Therefore, you must be east of the standard time meridian. It is always later to the east, consequently your LMT must be 0h 29m 16s later than ZT. This representation is as follows:

ZT	06h	21m	09s
	00h	29m	16s
LMT	06h	50m	25s

TIMEPIECES

Time-measuring devices have evolved from the simplest sundials to complicated electronic equipment. Aboard Navy ships, time is kept by watches, clocks, and chronometers.

CLOCKS AND WATCHES

A ship's routine activities are timed by the various ship's clocks or deck clocks, mounted on the bulkheads and usually set to ZT. When the ship enters a new time zone, a Quartermaster makes the rounds of all clocks, resetting them 1 hour one way or the other, contingent upon whether the ship is moving east or west. The *commanding authority* may, however, direct that the clocks be changed at some time except the instant of entry into a new zone. Some arbitrary time, like daylight saving, may be selected for reasons of convenience. In some localities the ship's clocks are set to fractional zone time.

Ships are equipped with a number of clocks, depending upon the ship's size and mission. The pilothouse, engineering spaces, offices, messing spaces, and staterooms are areas that normally have clocks. Ships' clocks are of various types: 12- and 24-hour dials, direct reading, 8-day (winding period), electric, etc. Whatever their location or type, however, keeping them set to correct time, adjusting their rates, and having them repaired when necessary is the Quartermaster's responsibility.

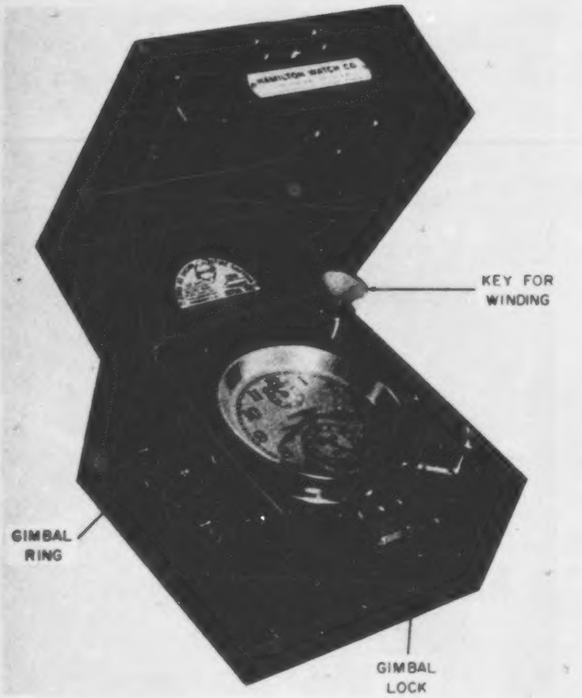
One person usually is assigned the job of winding and setting the clocks at intervals prescribed by the navigator. Ship's clocks are accurate enough to time meals, watch relief, taps, liberty call, etc. The person assigned the duty of setting the clocks sets a comparing watch to the correct time (either from a chronometer or radio time signal) and checks the accuracy of each clock by comparing it with the comparing watch. He then notes (in a clock log) the error of each clock, winds each clock, and adjusts it to run faster or slower, depending on whether it was gaining or losing time. No adjustment for rate is made to clocks that have only a small error, because frequent adjustments may cause erraticisms.

Comparing watches and stopwatches may also be used for timing celestial observations, as described in the final topic in this chapter.

CHRONOMETER

Chief among navigational timepieces is the chronometer (figure 8-4). It is considered one of the most accurate mechanical time machines devised by man. If a ship does not have a chronometer and must navigate at any time by celestial observations, she is provided with a timepiece that reasonably approximates the chronometer's accuracy.

The chronometer is a clock of unusually fine construction. It is designed for extreme accuracy



69.38

Figure 8-4.—Ship's chronometer in its case.

69.39

Figure 8-5.—Stowage of ship's chronometer.

and dependability, and is built to withstand shock, vibration, and variations of temperature. Like the magnetic compass, it is mounted in gimbals to offset ship's motion. It must be handled with the greatest care because its accuracy and regularity are essential in determining GMT(UT), the basic time used in fixing position by celestial navigation.

Types of Chronometers

Two types of chronometers presently are in use: size 85 and size 35.

The size 85 chronometer (formerly called ship chronometer) is the principal navigation timepiece aboard ship. It can easily be identified by its 4-inch dial and the jerky motion of its second hand, which jumps ½ second every other tick. A modified size 85 chronometer is furnished to missile carrying ships if those ships have shipboard time/frequency standards. This modification features an electrical contact assembly (make-break circuit) capable of producing an electrical impulse every second except the 59th second of each minute. The make-break circuit keeps the DRT and other equipment on missile ships set to the correct time.

Formerly, size 35 chronometers were called chronometer watches. They are identified by their 2-½ inch dial and external winding stem, making them resemble large pocket watches. Although size 35 chronometers still are found on many ships, they are being phased out of the Navy.

Care of Chronometers

The NAVSEA Technical Manual, current NAVSEA directives, and Navy Regulations contain complete instructions concerning the care, winding, and transportation of chronometers. You must familiarize yourself with these instructions. A brief summary of their content follows.

Before the chronometer is received on board, complete preparations should be made for its immediate installation. The chronometer locker (figure 8-5) should be located as near as possible to the ship's centerline, where the effect of rolling is minimized. Chronometers should not be installed near masses of vertical iron or charged electrical machinery. They should be placed where they are least subjected to drafts, temperature changes, the jar of vibration of machinery, and the shock of gunfire.

Chronometers should always remain in their gimbal boxes. The glass cover of the chronometer gimbal box should be kept closed at all times. This cover protects the chronometer from moisture and prevents sudden, rapid changes of temperature. The gimbal boxes should be removed from the chronometer locker only under the following circumstances: for safekeeping during extended periods of ship repair; during deperming of flashing operations; or when the chronometers are scheduled for overhaul.

When chronometers are received on board, they have a small piece of gummed paper attached. On this paper is written or stamped the overhaul due date. Chronometers should be turned in for overhaul within 6 months of the date indicated because, beyond that time, their rates tend to become erratic and their accuracy deteriorates.

If chronometers are moved for any reason, their gimbal rings must be locked. For transportation from ship to pool, or vice versa, the instruments should be hand-carried by a responsible person. He must guard them particularly against shocks, jars, or quick rotary motions. The NAVSEA Technical Manual gives instructions for transporting chronometers over a considerable distance (as by express).

Winding Chronometers

Chronometers are started and set to GMT(UT), at the chronometer pool, and are never reset thereafter. Although they usually are designed to run for 56 hours without rewinding, each one must be wound regularly at approximately the same time each day to ensure uniform performance. If a chronometer should run down, the consequences would be serious; hence, a better means than memory alone must be used as a reminder of the time for daily winding. The number of hours elapsed since the last winding is shown by an indicator dial on the face of each chronometer.

To wind the size 85 chronometer, turn the instrument gently on its face and steady it with your hand. Uncover the keyhole by turning the dustplate on the bottom, and insert the key. Wind counterclockwise. Seven half-turns will suffice if no more than 24 hours have elapsed since the last winding. Take the last turn slowly to avoid bringing the winding mechanism up hard against the stops. After winding, cover the keyhole and return the instrument to its normal position. (Except when being wound, chronometers should always rest faceup in their gimbals.) Check the indicator dial at the top of the face to ascertain that the indicator is back to 0.

To wind the size 35 chronometer, grasp it in your left hand. Turn it in its gimbal until it is vertical, stem up. With the thumb and index finger of the right hand, wind the instrument as you would a fine watch, again being careful not to bring the winding mechanism up hard against the stops. Twenty-one half-turns normally wind 24 hours.

Most ships have more than one chronometer. They should be wound in the same sequence each day to prevent omissions. The Quartermaster customarily winds the chronometers at 1130. A report of this action must be made to the commanding officer by the OOD at 1200.

Error and Rate

Even a chronometer cannot keep exact time indefinitely. Sooner or later the chronometer time gradually begins to draw away from GMT(UT). Chronometers are set to GMT(UT), as nearly as possible, before delivery aboard ship. The difference between chronometer time and GMT, at any instant, is called chronometer error. Error direction is identified with a sign or letter (+ or F = Fast) or (- or S = Slow) to indicate that the chronometer is either fast or slow in relation to the correct GMT.

Chronometer rate, on the other hand, is the amount the instrument gains or loses in a specified time. For example, a chronometer whose rate is +1.5 seconds will gain 1.5 seconds every 24 hours. Chronometer rate is usually expressed as seconds and tenths of seconds per day, and is labeled "gaining" or "losing."

Chronometer rate is determined by comparing errors obtained several days apart and dividing the difference by the number of days between readings. See the example below.

Date	Correct GMT(UT)	Chron. time	Error	Chron. rate
17 July	11h 30m 00s	11h 32m 00s	02m 00s	
18 July	11h 30m 00s	11h 32m 01s	02m 01s	+1s

Average daily rate (ADR) is found by using the formula–

$$\text{ADR}=\frac{(\text{error on last day observed})-(\text{error on first day observed})}{(\text{date of last observation})-(\text{date of first observation})}$$

The example worked from applying the ADR formula is for a 31-day month. A navigator desiring to determine the chronometer rate compares the chronometer directly with the Washington, D.C., (NSS) 1200 radio time signal on different days. On the first day the chronometer reads fast by 09 minutes 3.0 seconds, and on the last day it reads fast by 9 minutes 53.5 seconds. Average daily rate (ADR) is found as follows:

$$\text{ADR}=\frac{(\text{F})\ 09\text{m}\ 53.5\text{s}-(\text{F})\ 09\text{m}\ 3.0\text{s}}{(31)-(1)}=\frac{50.5\text{s diff}}{30\text{ days}}=1.68\text{s/gaining}$$

No attempt should be made to determine chronometer error closer than ½ (0.5) second. Average daily rates, therefore, are a somewhat more accurate measurement of the chronometer's performance than are the daily checks because, in the former method, any daily observational errors are averaged out.

Determining Chronometer Error

Inasmuch as chronometers are never reset aboard ship, an accumulated error may become quite large. Such an error is unimportant, though, if an accurate record is kept of the error.

The most accurate check on the chronometer and other timepieces is the radio time signal broadcast by radio station NSS and other stations listed in Radio Navigational Aids (Pub. No. 117).

Since 1 Jan. 1973, the broadcast time signals (UT) have differed from GMT by amounts up to ±0.7s. The difference arises because the time argument of the navigational tables depends on the variable rate or rotation of the Earth, while the broadcast time signals are now based on an atomic time-scale. Step adjustments of exactly 1 second are made to the time signals as required (normally at 24h on December 31 and June 30) so that the difference between the time signals and GMT may not exceed 0.9s. For those who require GMT to an accuracy better than 1s, a correction (DUT) is coded into the transmitted time signal. GMT accurate to 0.1s is obtained by applying DUT to the transmitted time signal; i.e.,

$$\text{GMT} = \text{UT} + \text{DUT}$$

Naval radio stations transmit time signals (on seven different frequencies) for the 5 minutes immediately preceding certain hours GMT. The DUT correction is given in Morse code in the final 9-second pause prior to the long dash.

Each second in the time signal is marked by the beginning of a dash; the end of the dash has no significance. Beginning at 5 minutes before the hour, every second is transmitted except the 51st second of the 1st minute, 52nd second of the 2nd minute, 53rd second of the 3rd minute, 54th second of the 4th minute, 29th second of each minute, the last 4 seconds of each of the first 4 minutes, and the last 9 seconds of the last minute. The hour signal after the 9-second break (59m 60s) consists of a longer dash than the others. For clarity, the system of dashes is shown graphically in the accompanying table.

Minute	Second										
	50	51	52	53	54	55	56	57	58	59	60
55	·		·	·	·	·					·
56	·	·		·	·	·					·
57	·	·	·		·	·					·
58	·	·	·	·		·					·
59	·	(+DUT)									

All other time signal transmissions, e.g., WWV (Ft. Collins, Col.), WWVH (Honolulu), CHU (Ottawa, Can.), are broadcast on 2.5, 5, 10, 15, 20, and 25 megahertz and consist of dashes at the beginning of each second (commencing with the zero second of each minute). DUT is coded into the first 16 seconds by doubling of the dashes in seconds 1 to 8 for

+0.1s to +0.8s, and in seconds 9 to 16 for -0.1s *to -0.8s. For example: If DUT = +0.4s*, the dashes for seconds 1,2,3,4 would be double; if DUT = -0.6s, the dashes for seconds 9,10,11,12,13,14 would be double.

The upcoming time is announced during the interruption of the audiofrequency. The exact time is taken the instant the audiofrequency is resumed. An example of the voice announcement might be: "This is radio station WWV. When the tone returns, the time will be 8:50 a.m. eastern standard time; 8:50 a.m."

Information concerning each chronometer (error, successive daily rate, average daily rate) must be recorded in the Navigational Timepiece Rate Book, NAVSEA 9846/2. (See figure 8-6.) Each page of NAVSEA 9846/2 can accommodate the records of a maximum of three chronometers for 1 month.

The most accurate timepiece on board is checked against the time signal, and its error is recorded in NAVSHIPS 9846/2. Errors of the other chronometers can be calculated by referring to the chronometer just checked.

Chronometers checked against the transmitted time signal will show a jump of ±1 second on 31 Dec. 23h 59m (and possibly 30 June 23h 59m) when a leap second is introduced. This adjustment, which is required to keep the broadcast time signals in step with the variable rate of rotation of the Earth, is accompanied by a change in the sign of DUT.

Chronometer Minus Watch Computation

The importance of obtaining the exact GMT(UT) of every celestial observation was mentioned earlier. Obviously it would be impractical if, every time you took a sight on the bridge wing, you had to dash into the charthouse and look at the chronometer. Every observation, consequently, is timed the instant it is made, either by a stopwatch or by a comparing watch.

The stopwatch can be started exactly on some convenient minute or hour of the chronometer. If its rate is known to be small, there is no necessity for working out any chronometer minus watch (C-W) computation, provided the interval during which observations are taken is short. For a single observation, the stopwatch can be stopped (or, reversing the procedure, the watch may be started) when the sight is taken, but seldom is only one observation made. For this reason, the stopwatch usually must be read like any other watch.

A comparing watch can be set to the chronometer time and can be used to keep time if its rate also is small. Some navigators, though, prefer to keep their watches on zone time; hence, observation time must be computed. It doesn't matter whether computation is made before or after the observation. It is essential, though, to have the interval as short as possible between time of sight and time of computation. Otherwise, enough time may elapse for the watch to gain or lose a sufficient amount to cause an error. For better accuracy and to avoid careless errors, it's a good idea to make C-W computations both before and after a round of sights.

The C-W computation is watch time (WT) to the half-second subtracted from chronometer time (CT). If WT is greater, 12 hours must be added to CT. The C-W is never greater than 12 hours because both watch and chronometer are graduated only to 12. Now that you know the value of C-W, it is necessary only to add this value to the WT of any observation to find the correct CT, then apply CE, and you have the GMT(UT) of the observation.

To work an example, assume that you have a chronometer whose error (CE) is -7m 4s; in other words, it is 7m 4s behind GMT(UT). Your watch is set to ZT and reads 5h 26m 42s when the chronometer reads 10h 19m 00s. First, find the C-W. It's WT subtracted from CT.

CT	10h	19m	00s
WT	5h	26m	42s
C-W	4h	52m	18s

You step out on the bridge with your sextant and watch, and sight on Sirius at WT 5h 34m 21s, date 15 October, longitude 101°34.2′E. What is the GMT(UT) of this sight? Applying the formula CT=WT+C-W, we find:

WT	5h	34m	21s
C-W	4h	52m	18s
CT	10h	26m	39s

DATE	A					B					C					OBSERVATION	
YEAR 19__	MAKE HAMILTON TYPE SIZE 85 SERIAL NO. 192 W					MAKE HAMILTON TYPE SIZE 85 SERIAL NO. 1135					MAKE HAMILTON TYPE SIZE 35 SERIAL NO. 156B						
MONTH JULY	ERROR RELATIVE TO G.C.T. + = FAST − = SLOW			SUCCESSIVE DAILY RATES		ERROR RELATIVE TO G.C.T. + = FAST − = SLOW			SUCCESSIVE DAILY RATES		ERROR RELATIVE TO G.C.T. + = FAST − = SLOW			SUCCESSIVE DAILY RATES		LOCAL TIME TO NEAREST MINUTE	
DAY	±	MIN.	SECONDS	±	SECONDS	±	MIN.	SECONDS	±	SECONDS	±	MIN.	SECONDS	±	SECONDS	TIME	INITIALS
1	+	11	49.0	+	1.5	−	6	02.0	−	1.0	+	16	22.0	+	2.0	1130	RC
2	+	11	51.5	+	2.5	−	6	02.5	−	0.5	+	16	24.0	+	2.0	1130	RC
3	+	11	53.0	+	1.5	−	6	03.0	−	0.5	+	16	25.0	+	1.0	1125	RC
4	+	11	54.5	+	1.5	−	6	04.0	−	1.0	+	16	23.0	−	2.0	1130	GG
5	+	11	55.5	+	1.0	−	6	04.0		0.0	+	16	21.5	−	1.5	1130	GG
6	+	11	57.5	+	2.0	−	6	04.5	−	0.5	+	16	20.0	−	1.5	1130	KYG
7	+	11	59.0	+	1.5	−	6	05.0	−	0.5	+	16	21.0	+	1.0	1135	MTG
8	+	12	01.0	+	2.0	−	6	05.5	−	0.5	+	16	20.5	−	0.5	1140	TH
9	+	12	02.5	+	1.5	−	6	06.5	−	1.0	+	16	22.0	+	1.5	1130	RC
10	+	12	04.5	+	2.0	−	6	06.5		0.0	+	16	22.0		0.0	1130	RC
11	+	12	05.5	+	1.0	−	6	07.0	−	0.5	+	16	23.0	+	1.0	1135	RC
12	+	12	07.0	+	1.5	−	6	07.5	−	0.5	+	16	23.5	+	0.5	1130	DAH
13	+	12	08.5	+	1.5	−	6	07.5		0.0	+	16	24.0	+	0.5	1130	RC
14	+	12	10.5	+	2.0	−	6	08.0	−	0.5	+	16	24.5	+	0.5	1125	RC
15	+	12	11.5	+	1.5	−	6	08.5	−	0.5	+	16	24.0	−	0.5	1145	RC
16	+	12	13.0	+	1.5	−	6	09.0	−	0.5	+	16	22.5	−	1.5	1130	RC
17	+	12	15.0	+	2.0	−	6	09.5	−	0.5	+	16	21.0	−	1.5	1130	RC
18	+	12	17.5	+	2.5	−	6	10.0	−	0.5	+	16	20.5	−	0.5	1130	RC
19	+	12	19.0	+	1.5	−	6	11.0	−	1.0	+	16	19.5	−	1.0	1125	RC
20	+	12	21.0	+	2.0	−	6	11.5	−	0.5	+	16	19.0	−	0.5	1130	RC
21	+	12	23.5	+	2.5	−	6	12.0	−	0.5	+	16	19.0		0.0	1130	RC
22	+	12	24.5	+	1.0	−	6	12.5	−	0.5	+	16	19.0		0.0	1150	MTG
23	+	12	26.0	+	1.5	−	6	13.0	−	0.5	+	16	20.0	+	1.0	1130	MTG
24	+	12	28.0	+	2.0	−	6	13.5	−	0.5	+	16	21.0	+	1.0	1125	RC
25	+	12	30.5	+	2.5	−	6	13.5		0.0	+	16	21.5	+	0.5	1130	RC
26	+	12	32.0	+	1.5	−	6	13.5		0.0	+	16	22.5	+	1.0	1130	RC
27	+	12	34.0	+	2.0	−	6	14.0	−	0.5	+	16	23.0	+	0.5	1135	RC
28	+	12	35.5	+	1.5	−	6	15.0	−	1.0	+	16	24.0	+	1.0	1130	RC
29	+	12	37.0	+	1.5	−	6	16.0	−	1.0	+	16	25.5	+	1.5	1140	GG
30	+	12	39.0	+	2.0	−	6	16.5	−	0.5	+	16	26.5	+	1.0	1130	GG
31	+	12	41.5	+	2.5	−	6	17.0	−	0.5	+	16	27.0	+	0.5	1130	DAH

+1.75 AVERAGE DAILY RATE −0.5 AVERAGE DAILY RATE +0.17 AVERAGE DAILY RATE

NOTE: FOR COMPUTATION OF AVERAGE DAILY RATE SEE PARAGRAPH 5 UNDER INSTRUCTIONS.

[illegible]

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Figure 8-6.–Ship's chronometer record.

The CT is the chronometer time of the observation. Apply CE to CT to find GMT(UT). The CE is minus, meaning that the chronometer is behind GMT(UT); therefore, CE must be added to CT. Thus:

CT	10h	26m	39s
CE		7m	04s
GMT	10h	33m	43s

Now, let's consider the date 15 October at 101° 32.2′E. Is it the same day at Greenwich? Let's see. The zone time is 5h 34m 21s. The ZD is -7. Subtract ZD from ZT to get GMT(UT). You can't subtract 7 from 5, but 5h on 15 October is the same as 29h on 14 October, and 7 from 29 is 22. Therefore, 10h 33m 43s is not a.m. on 15 October, but p.m. on 14 October. From this computation, it follows that GMT(UT) is 22h 33m 43s on 14 October.

In problems like these you must check the date carefully every time to avoid a 12-hour error such as the one we encountered just now.

CHAPTER 9

INTRODUCTION TO NAVIGATION

Navigation is the art and science that enables the mariner (or aviator) to (1) determine his ship's position and (2) guide her safely from one point to another. You already have a good idea of how a ship's compass is used in guiding her from one point to another, but how does her navigator figure out where he is in the first place?

DETERMINING POSITION

We have four ways of determining position in navigation, every one of which locates a ship's position with relation to some locality, or object(s) whose location is already known. These four methods of finding position are—

1. Piloting, in which position is determined by means of bearings on or distances from visible objects on the Earth's surface, or by soundings.

2. Dead reckoning, in which position is determined through the direction and distance a ship has traveled from a known point of departure.

3. Celestial navigation, in which position is found by locating a ship with relation to the celestial bodies.

4. Electronic navigation, in which position is determined much as it is in piloting except that the bearings and/or distances are obtained by electronic means.

By utilizing any of the foregoing methods of navigation, the ship's position can be kept on charts in the pilothouse. (See figure 9-1.)

The four ways of determining position will receive individual treatment as this course progresses. Right now we want to discuss some of the fundamentals you must know about objects located on the terrestrial sphere.

TERRESTRIAL SPHERE

Let's say you're looking at a white cue ball with an absolutely blank surface. Take a pencil and make a mark on it. Now, how would you tell anybody where on the cue ball the mark is located? The answer is: You couldn't. There are no points or objects on the cue ball with reference to which you can locate the mark.

The Earth is a sphere, just as this cue ball is. It is called the terrestrial sphere. Although it is a little flattened at the poles instead of being perfectly spherical, this irregularity is disregarded here for simplicity. Reference points for location of objects on the Earth, with two exceptions, have been established by general agreement among maritime nations. These two exceptions are the North and South Poles, located at the ends of the axis on which the Earth rotates. Imaginary lines (an infinite number of them) running through the poles and around the Earth are called meridians. They divide the Earth into sections, the way an orange is divided into segments.

Now, suppose you start at the North Pole and travel along a meridian exactly halfway to the South Pole. You'll then be on the Equator, an imaginary line, running clear around the Earth, which bisects every meridian and divides the Earth in half. The half the North Pole is on is called the Northern Hemisphere; the other half, the Southern Hemisphere.

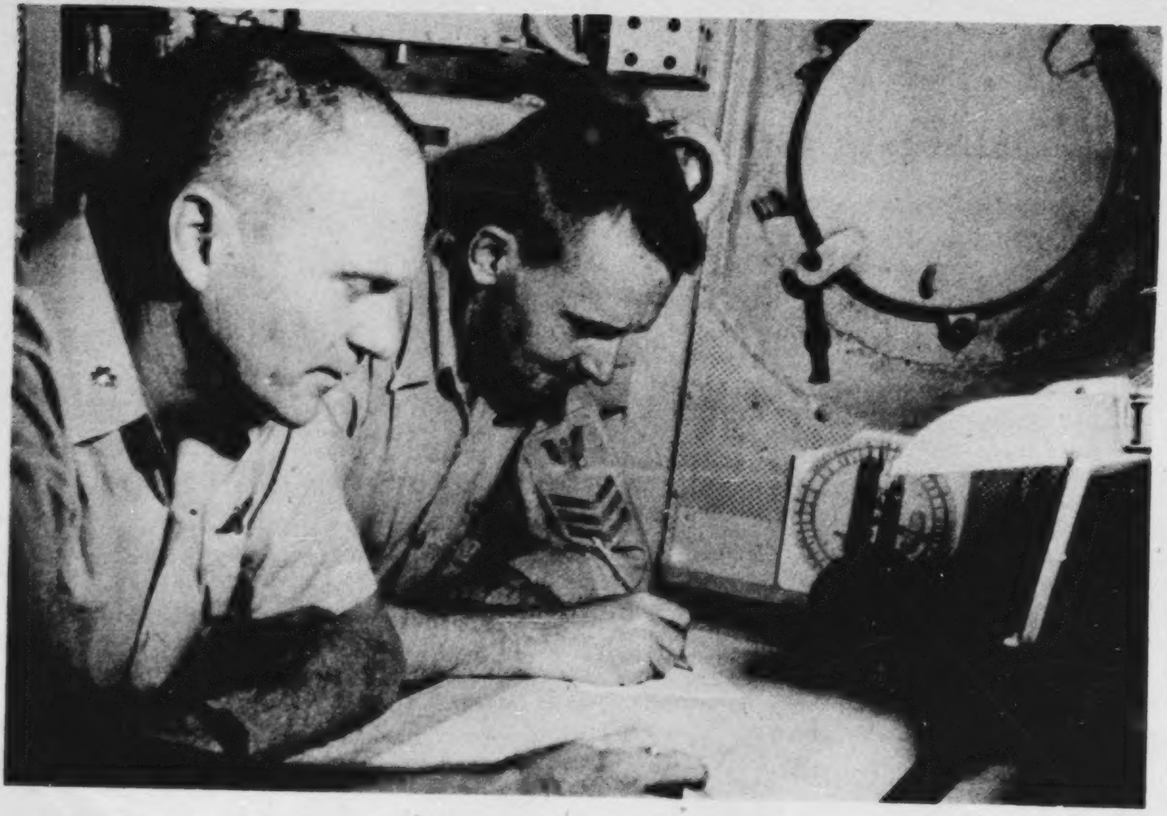

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Figure 9-1.—Plotting a course in the chart room. The navigator must maintain an accurate plot of the ship's position, for he is responsible to the commanding officer for the safe navigation of the ship.

CIRCULAR MEASUREMENT

Before going any further, you'll have to know something about how distances are measured along the circumference of a circle. Measurement along a meridian, which is a perfect circle, is expressed in terms of degrees of arc. These degrees of arc may be transformed into linear measurement in nautical miles (described later). The best example of circular measurement in degrees of arc is the compass card. Whatever the size of the card, its circumference always contains 360°. Each degree contains 60 minutes ('); each minute, in turn, contains 60 seconds ("). The nautical mile, by arbitrary international agreement, is now taken as 6076.11549 feet or exactly 1852 meters. The nautical mile is about one-seventh again as long as the statue mile.

MERIDIANS AND PARALLELS

So far, in developing a system for locating points on the terrestrial sphere, we have a series of meridians, running through the poles around the Earth, and a single line called the Equator, running around the Earth at right angles to its axis. These reference lines can be seen in figure 9-2. The equator divides each meridian and the Earth itself into two exact halves.

For every degree around the Earth's rim, there is a meridian—360 of them 60' or 3600" apart. A starting point for numbering these specific meridians was required, and most of the

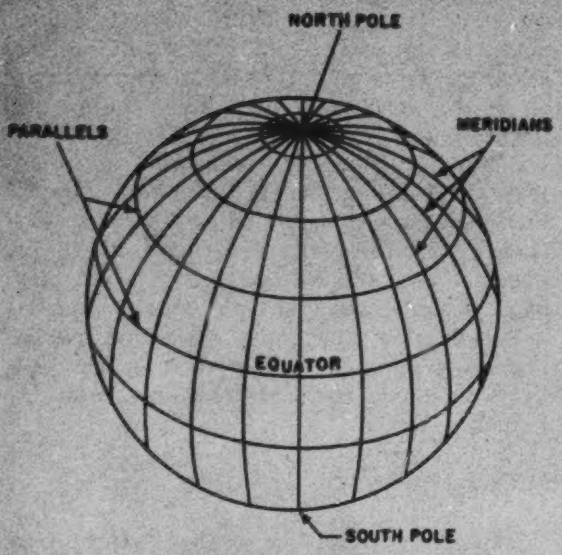

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Figure 9-2.—The terrestrial sphere.

maritime countries decided that the starting point should be the meridian on which was located the Royal Observatory at Greenwich, England. The Greenwich meridian is, therefore, number 0; and meridians run from that one east and west to the 180th, on the opposite side of the Earth from Greenwich. The complete circle formed by the 0 and 180th meridians, like the Equator, divides the Earth into two exact halves, one of which is the Eastern and the other the Western Hemisphere. Every meridian runs true north and south.

Let's leave the meridians, now, and go back to the Equator. Let's cut a globe of the world in half exactly along the Equator, and set the northern half on the chart table, flat edge down. Get your eye lined up so that the flat edge appears as a straight line, and you will see the upper edge of the shape of a semicircle, containing 180° of arc, 90° from equator to pole on either side.

Beginning with the Equator, you see lines that appear to be parallel to it, one for each of the 90° of arc from the Equator to the North Pole. The planes forming these lines on the Earth's surface are actually parallel to each other, and for this reason they are called parallels. As a matter of fact, if you shift your eye to a point just above the pole, you can see that they are actually circles, growing increasingly smaller as they get farther from the Equator and nearer the poles. Don't forget though, that, no matter how small a circle is, it still contains 360°. The distance represented by each degree becomes less, however, as the parallel circles get smaller.

Starting point for numbering the parallels is the equator, the 0 parallel. Parallels are numbered from 0° to 90° N and S of the Equator, and every parallel runs true east and west.

Don't get the idea that there are only 360 meridians and 180 parallels. There is a meridian or parallel for every one of the 21,600 minutes around the complete circle of the Earth's sphere.

The parallels and meridians are imaginary, but there is a limit to the capacity of our instruments, and we seldom break down measurement along a meridian or parallel to a value smaller than that of a second.

LATITUDE AND LONGITUDE

Now we have a network of meridians and parallels all the way around the globe. Every spot on the Earth is located at the point of intersection between a meridian and a parallel. Every point's location is described in terms of its latitude (distance in degrees, minutes, and seconds of arc N or S of the Equator, measured along the point's meridian) and longitude (distance in degrees, minutes, and seconds of arc E or W of 0 meridian, measured along the point's parallel). Longitude is always from 0° to 180°. Latitude never is greater than 90°. Zero latitude is the Equator. If you are on latitude 90°N, you are at the North Pole, and whichever way you look is south.

GREAT CIRCLE

The concept of the great circle is sometimes difficult for a beginner to grasp, but it is a fundamental that must be clearly understood. A great circle is any circle whose plane passes through the center of the Earth or any other sphere.

What does this statement mean, exactly? Suppose you have a perfect sphere of soft rubber through which you can pass a flat sheet of thin metal. If you shove the metal sheet through the sphere so as to cut it exactly in half, you have passed it through the center. The circumference of the flat side of each half becomes a great circle whose circumference is the same size as the circumference of the sphere itself.

On the other hand, if you shove the flat metal through the sphere so that it doesn't pass through its center, the circumference of the flat side of each part is smaller than the outside circumference of the sphere.

In both examples cited, the flat sheet represents the plane of the circle the sheet makes when it cuts the sphere. Now, imagine we cut the Earth with a similar plane. No matter how we slice it, if the plane passes through the Earth's center, the cutoff circle is a great circle. If the plane passes through the Earth away from the center, the circle it cuts is a small circle.

The Equator is a circle whose plane passes through the Earth's center; consequently, the Equator is a great circle, and it is the only parallel that is a great circle. The other parallels N and S of the Equator are all small circles whose planes do not pass through the Earth's center. All meridians, on the other hand, pass through the poles, and all their planes must, therefore, pass through the Earth's center. Consequently, every meridian is a great circle.

Don't get the idea that a great circle must be either a meridian or a parallel. A great circle is any circle around the Earth whose plane passes through the Earth's center, no matter in what direction the plane passes.

What is the practical significance of the great circle in navigation? Just this: The shortest distance between two points on the Earth (or on any other sphere, for that matter) is along the great circle passing through the points.

You'll understand this subject better after you study the different methods of chart projection. Right now it is necessary only that you understand the fundamental concept of the great circle.

DISTANCE

We've already mentioned the nautical mile. It is equal to approximately 1 ′ of arc along the Equator, the equivalent in length of about 1-1/7 statue or land miles. The Equator is a great circle, as we have seen. Therefore, if 1 ′ of arc along the Equator is 1 nautical mile, 1 ′ of arc along any great circle must also be 1 nautical mile. All great circles are the same length.

How does this relationship work out, then? It means that on any chart the meridians may be used as a distance scale. All meridians are great circles; therefore, 1 ′ of latitude along any meridian equals 1 nautical mile. On the other hand, when it comes to parallels, 1 ′ equals 1 mile only along the Equator, the only parallel that is a great circle. Or, to put it another way, 1 ′ of longitude equals 1 mile only along the Equator.

SPEED

The word "knots" is a seagoing speed term meaning nautical miles per hour. It is incorrect to say "knots per hour" except when referring to acceleration. In the old days a ship gaged her speed by heaving over a chip log, consisting of a flat piece of wood, which offered a maximum resistance to passage through the water. There was a light "log line" attached to the chip. It was impracticable to stream out 1 mile of log line; so the line was knotted, marking suitable fractions of 1 nautical mile. A man held aloft a reel containing the log line. The instant the log was heaved from the taffrail by the Quartermaster, one of the ship's hands turned over a small 2- or 3-minute sandglass. As soon as the sand in the glass ran out, the reel was stopped; and , from the amount of line run out in 2 or 3 minutes, the number of knots that would have run out in 1 hour was calculated.

For obvious reasons, the chip log have but a rough approximation of a ship's actual speed. It is entirely obsolete now and is mentioned here only to give you the historical background of the expression "knots."

DIRECTION

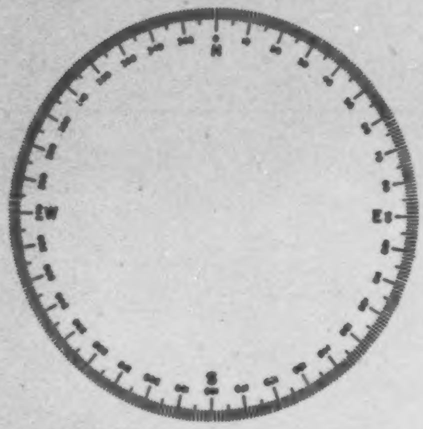
Nautical direction usually is measured from true north on the observer's meridian.

On the old-fashioned compass card, direction was indicated by points. There were 32 major points around the card, each of which had a name: N, N by E, NNE, NE by N, NE, and so on. Each point was subdivided into quarter points, and the system of naming these divisions toward or away from the points themselves was quite complicated and difficult to remember.

Navigators have long since adopted the system of circular measurement (360° of arc) as a much more convenient means of indicating direction than the ancient system of points. (See figure 9-3.) In the Navy even relative bearings, formerly expressed as "4 points on the bow," "2 points abaft the beam," etc., are now given in terms of their corresponding degrees. There are 11-1/4° in each of the old-style compass points.

Direction in modern navigation, then, is always given in degrees, measured clockwise from true north, or 000°T. A course or bearing, incidentally, is always expressed in three figures, regardless of whether three digits are necessary. In other words, it is not 45° but 045°. Seldom is it possible to consider compass direction to a value smaller than the 10th of a degree even though each degree of direction contains 60 minutes of 60 seconds each. As a matter of fact, it is almost impossible to read a compass bearing or heading to closer than a quarter of a degree.

A true bearing is the direction of an object from the observer, measured clockwise from true north.



45.29.1

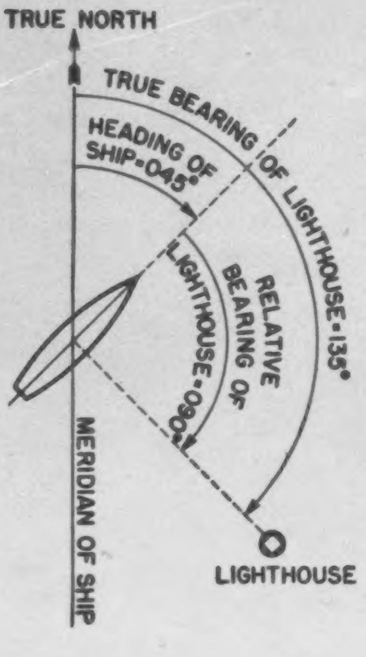
Figure 9-3.—Degrees on the compass card.

A compass bearing is the direction of an object as indicated by magnetic compass. It must be converted into a true bearing by applying the corrections for variation and deviation (illustrated in chapter 4).

A relative bearing is the direction of an object from the observer, measured clockwise from the ship's head, as indicated by the lubber's line in the binnacle, pelorus, or gyro repeater.

Objects seen by lookouts are reported in terms of relative bearings by degrees.

There will be times when the Quartermaster will find it necessary to convert from true to relative bearings and vice versa. This relationship is shown in figure 9-4. Note that dead ahead is 000°, dead astern is 180°, and the starboard and port mid-points (beams) are 090° and 270°, respectively.


TRUE NORTH
TRUE BEARING OF LIGHTHOUSE-135°
HEADING OF SHIP-045°
RELATIVE BEARING OF LIGHTHOUSE-090°
MERIDIAN OF SHIP
LIGHTHOUSE

45.29(65)B

Figure 9-4.—True and relative bearings.

The reciprocal of any bearing is its opposite; that is, the point of degree on the opposite side of the compass card from the bearing. For example, the reciprocal of 180° is 000° and vice versa. When you obtain a bearing on some object, the bearing from the object to you is the reciprocal of the bearing from you to the object. To find the reciprocal of any bearing expressed in degrees, simply add 180° to the bearing. If the bearing is 050°, for instance, its reciprocal is 050° plus 180° or 230°. If your bearing is greater than 180°, subtract 180°.

CHAPTER 10

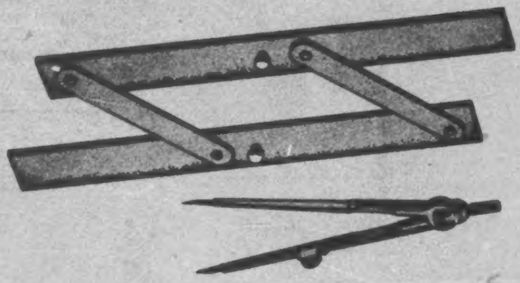
DEAD RECKONING AND PILOTING

At last we're getting around to some actual navigation. By the time you finish this chapter, you will know how a ship's position is determined by dead reckoning and by piloting. But, before going into that, you must know something about how courses, bearings, and lines of position are plotted on a chart. More properly, you must know, first, that they frequently are not plotted on the chart itself. Repeatedly drawing lines, then erasing them soon wears out the chart. Besides, it is desirable many times to keep a permanent file of a ship's movements. Consequently, actual plotting often is done on either an overlay position plotting sheet or a small area plotting sheet. Each sheet is also referred to as a track chart.

PLOTTING

The basic instruments used in plotting are parallel rulers, protractors, and dividers. The parallel ruler consists of two straightedges connected by metal straps. The two straightedges may be closed or opened, but they always remain parallel to each other. By placing the edge of one ruler along a line of bearing and "walking" the rulers carefully across the chart to the compass rose, the true bearing of the line may be determined. Figure 10-1 shows a set of parallel rulers and also a pair of dividers. Dividers are used for transferring chart distances to the appropriate scale on a chart.

A protractor performs practically the same function as parallel rulers, but without the necessity for any walking across the chart. A simple protractor consists of a graduated arc on a piece of celluloid. One, with an attached ruler that pivots on the center of curvature of the arc, is the Hoey position plotter. Its arc is graduated like the upper half of a compass rose, and horizontal and vertical lines are etched on the celluloid. By lining up these lines with meridians or parallels, any course or bearing can be plotted by swinging the ruler to the desired degree mark on the arc.

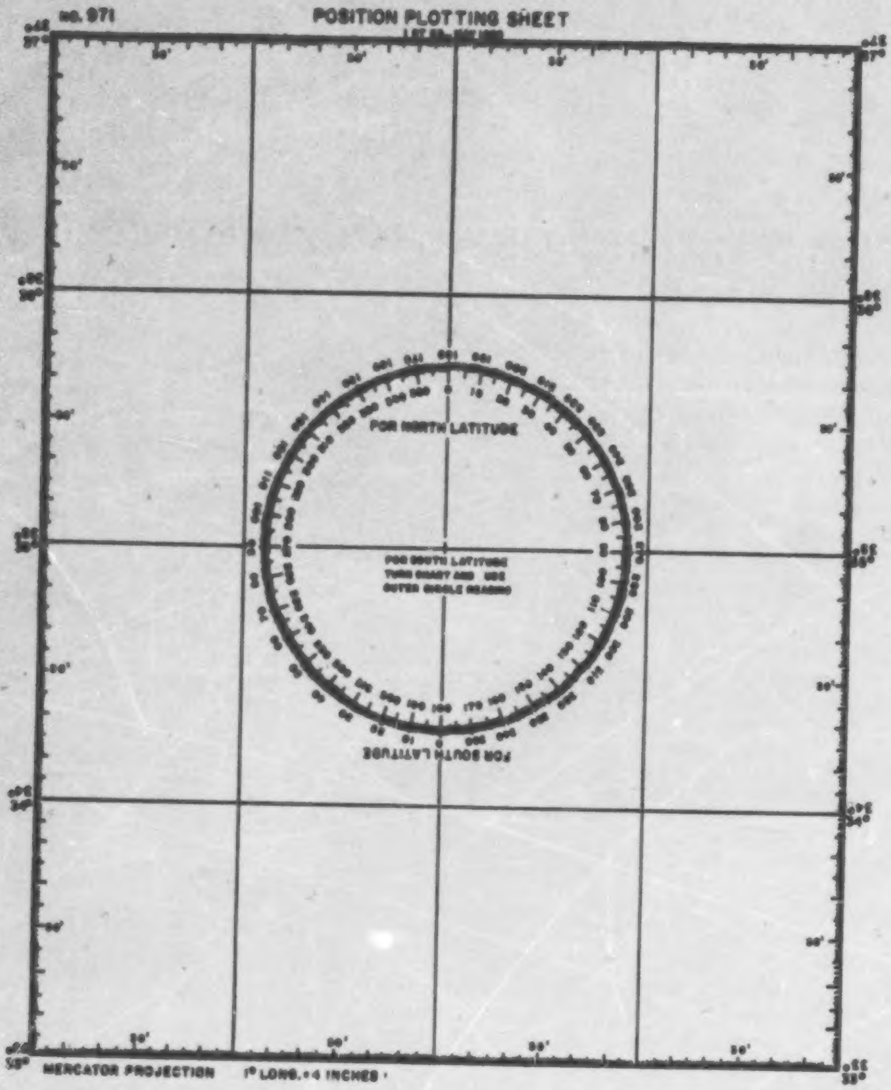


4.16:.18(66)

Figure 10-1.—Parallel rulers and dividers.

OVERLAY

An overlay consists simply of a piece of tracing paper large enough to cover the navigational chart being used. The chart is laid on the chart table and the overlay is fastened over it with tape. Meridians and parallels are traced lightly in pencil in the area to be plotted. Each meridian and parallel is marked carefully with its degrees and minutes of latitude or longitude. The general contour of any shoreline in the area, although not always essential, may be traced in also. Any navigational hazards in the area usually are marked. From here on, if


NO. 971
POSITION PLOTTING SHEET
FOR NORTH LATITUDE
FOR SOUTH LATITUDE TURN CHART AND USE OUTER CIRCLE READING
FOR SOUTH LATITUDE
MERCATOR PROJECTION
1° LONG. = 4 INCHES

65.130

Figure 10-2.—Plotting sheet

the overlay is to be filed, it is a good idea to trace over its essential features in ink to preserve the record better.

PLOTTING SHEET

Plotting sheets (figure 10-2), used primarily for plotting lines of position from celestial observations and for dead reckoning, are printed by DMAHC for various latitudes. These readymade plotting sheets have numbered parallels and unnumbered meridians. Thus the meridians, which are spaced as appropriate for the latitude, may be numbered as convenient for the navigator. They contain at least one compass rose for measuring direction.

DEAD RECKONING

Dead reckoning, as stated previously, is the method of navigation by which position is determined by means of the direction and distance traveled from a known point of departure.

A ship underway is moving through water, which is a very unstable element. She might leave point A, steer an exact course according to the true bearing between point A and point B, and still wind up a long distance from B, depending on how much leeway she makes. Likewise, estimating the distance traveled seldom produces an exact result.

The dead-reckoning (DR) position is only an estimated position, calculated from values that rarely are exact. A fix, on the other hand, is a relatively exact location derived from the intersection of two or more lines of position. A DR position is not a fix, but it is calculated from the last fix obtained. In piloting, a fix is obtained by bearings taken on objects whose locations are charted. In celestial navigation, position (fix) is determined by observations of the heavenly bodies. When a ship out of sight of land is prevented by bad weather from taking celestial observations, she must navigate by other means. Normally, electronic navigation is used when the ship is located in an area where it is available. If nothing else can be used, the ship must navigate by dead reckoning.

PLOTTING DR TRACK

In early sailing days, a "dead log" was one of the methods employed to measure ship's speed. This means of measuring speed consisted merely of timing the interval between which a piece of wood tossed overboard at the bow was off the stern. The length of the ship being known, it was a matter of simple calculation to estimate her speed.

The dead log is considered by some authorities as one source of the word "dead" in dead reckoning. Another theory holds that dead reckoning originally was "deduced" reckoning. Shortened in the logbooks to "ded" and "a" somehow crept in, making it "dead." Whatever the source, nothing is really dead about dead reckoning.

Following a ship's DR track from one fix to the next is a continous process while underway. A constant check on her approximate position is valuable to the navigator in many respects. For celestial observations, for instance, it enables him to locate his assumed position reasonably close to the ship's actual position.

How is the DR track plotted? Suppose that a fix , determined at 0900 by celestial observation, piloting, or electronic navigation, located your ship in latitude 32°42′ N, longitude 46°15′ W. ship in latitude 32°42′ N, longitude 46°15′ W. It is your last fix, and your DR track begins at this naturally, along the line of the true course steered. Assume that your course is 055°T. You simply set the parallel rulers or protractor on 055° and shift them to the fix, then draw a line from the fix bearing 055°T. As long as you stay on that course, your DR track will advance along this line. Suppose you're steaming at 20 knots. In 1 hour, or at 1000, your DR position will be 20 nautical miles from the 0900 fix, along the 055° course line.

The line bearing 055° from the fix is the course line or rhumb line. Label it "C 055" above the line, and "S 20" (for a 20-knot speed) below the line. Label the fix 0900 and the DR position at 1000.

The 1000 DR represents where you will be if you travel exactly 20 nautical miles on C 055°; that is, if you are not set to either side of the DR track. If you have a strong headwind or a head sea against the bow, chances are that you won't quite make 20 nautical miles. Although the steersman may keep her on exactly 055°T for every second of the hour, it is probable that a wind, current, or a combination of the two elements will work to set her to one side of the course. For this reason, it is mostunlikely for the DR position to coincide with the actual position, even after steaming only 1 hour.

In the Quartermaster 1 & C training course, you will see how the navigator tries to calculate direction and strength of forces tending to set a ship off the DR track. He computes set (direction in which the forces are acting) and drift (distance they will send the ship off in a given time), then allows for them in setting his course and speed.

MEASURING SHIP'S SPEED

In the preceding section we mentioned that you can locate a ship's DR position on the course line by figuring the nautical miles traveled in the time underway since the last fix. In simpler terms, this explanation means that distance traveled by a ship, in nautical miles, equals her speed in knots multiplied by her time underway.

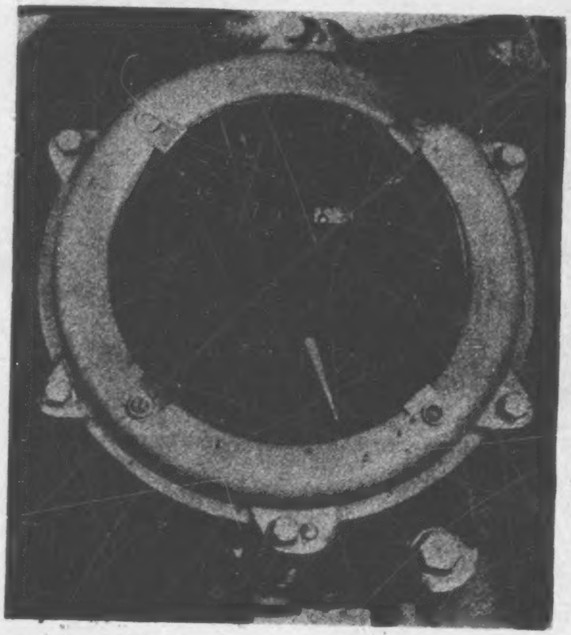
One method of measuring the approximate speed of a ship is by counting the revolutions per minute made by her engines. The speed produced by various revolutions per minute has been calculated already, normally by repeated running of a measured distance at various revolutions per minute. Speed by revolutions per minute is an approximation. A ship forcing her way against a swift current, with her engines turning flank speed, would actually make less headway than if she were running with the stream, her engines making the same revolutions per minute.

Another way of measuring speed is by a seagoing speedometer called an underwater log. Three general types of logs are installed in Navy ships: the Pilot static (differential pressure) type, the propeller (electromechanical) type, and the electromagnetic type.

In all three types of logs, a rodmeter (called a sword) protrudes through the hull of the ship beneath the keel and furnishes the speed signal to a mechanism within the ship that converts the signal into speed and distance traveled. In shallow or foul water, the sword must be retracted and housed in its shaft because the slightest scraping can damage the sword and render it inoperable. The electromagnetic log is the most accurate of the three types and is rapidly replacing the other two throughout the fleet.

ELECTROMAGNETIC LOG

The electromagnetic log consists essentially of a rodmeter, an oscillator amplifier, an indicator-transmitter, and associated repeaters. The rodmeter contains an electromagnetic sensing element, which produces a voltage directly proportional to the ship's speed through the water. This voltage is amplified in the oscillator amplifier and is converted to pointer indications of speed on the dial of the indicator-transmitter. Distance traveled (in forward motion) also is shown on the counter of the indicator-transmitter. The speed and distance signals are transmitted to repeaters (figure 10-3) located in the pilothouse, charthouse, CIC, and other ship control stations.



69.42

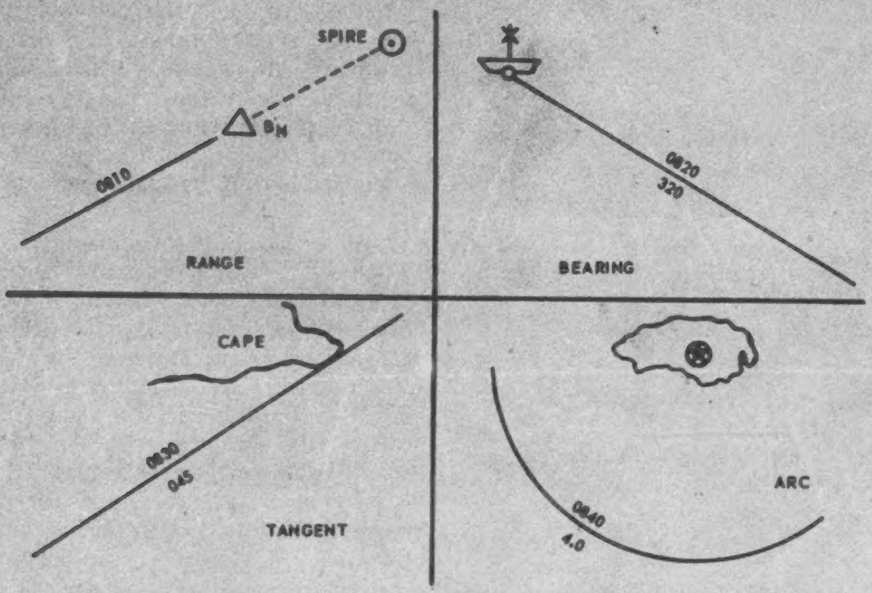
Figure 10-3.—Underwater speed log indicator.

ACTUAL SPEED

Generally speaking, both the engine revolutions and the log are indicators only of speed through the water. Actual speed over the ground that a ship makes cannot be determined unless wind and current are taken into consideration.

PILOTING

Piloting, you learned earlier, is a method of determining position and directing the movements of a vessel by reference to



69.141

Figure 10-4.–Lines of position.

landmarks, navigational aids, or soundings. Ordinarily, piloting is used as a primary means of navigation when entering or leaving port and in coastal navigation. It may be utilized at sea when the bottom contour makes it possible to establish a fix. In piloting, the navigator obtains warnings of danger, fixes the position frequently and accurately, and determines the proper course of immediate action.

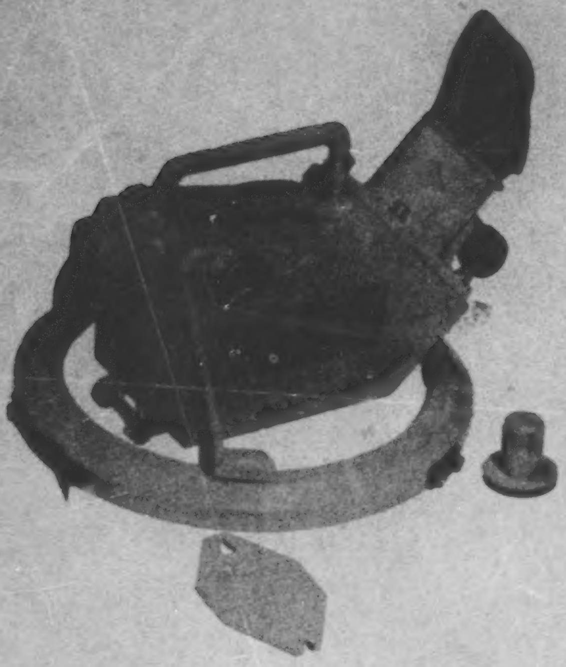
LINES OF POSITION

Piloting entails the use of 2 or more lines of position, whose intersection marks the ship's position. A line of position is determined with reference to a landmark. To be useful for this purpose, a landmark must be identified easily, and its position must be shown on the chart in use. Lines of position (figure 10-4) are of three general types: ranges, bearings, and distance arcs.

Two instruments used in taking bearings are the bearing circle and telescopic alidade. A bearing circle is a nonmagnetic metal ring equipped with sighting devices. It is fitted over a gyro repeater or a magnetic compass. Only bearings of objects on the Earth's surface normally are taken with the bearing circle.

Let's say you want to take a bearing on a lighthouse. First, install the bearing circle on the gyro repeater or magnetic compass, and make sure the vanes rotate freely. Next, line up the vanes in such a manner that, when you look through the opening in the near vane, you see the lighthouse directly behind the vertical wire in the vane. You then read the lighthouse bearing on the prism at the base of the far vane.

A telescopic alidade (figure 10-5) is a telescope equipped with crosshair, level vial, polarizing light filter, and internal focusing. The telescope is mounted on a ring that fits on a gyro repeater or magnetic compass. The optical system simultaneously projects an image of approximately 25° of the compass card, together with a view of the level vial, onto the optical axis of the telescope. By this means, both the object and its bearing can be viewed at the same time through the alidade eyepiece. Older models of the telescopic alidade have a straight-through eyepiece telescope, whereas the



45.39(69)A

Figure 10-5.—Telescopic alidade.

model shown in figure 10-5 has the eyepiece inclined at an angle for ease in viewing.

Ranges

A ship is said to be on the range when two landmarks are observed in line. This range is represented on a chart by means of a straight line through two appropriate chart symbols. The line is labeled with the time expressed in four digits above the line. It should be noted that range in this context differs significantly from its homonym meaning distance.

Bearing

It is preferable to plot true bearings, although either true or magnetic bearings may be plotted. If a relative bearing of a landmark is observed, it should be converted to true bearing by adding ship's true heading. In plotting, therefore, because bearing indicates the direction of a terrestrial object from the observer, a line of position is drawn from the landmark in a reciprocal direction. If a lighthouse bears 040°, for example, then the ship bears 220° from the lighthouse. A bearing line of position is labeled with the time expressed in four digits above the line.

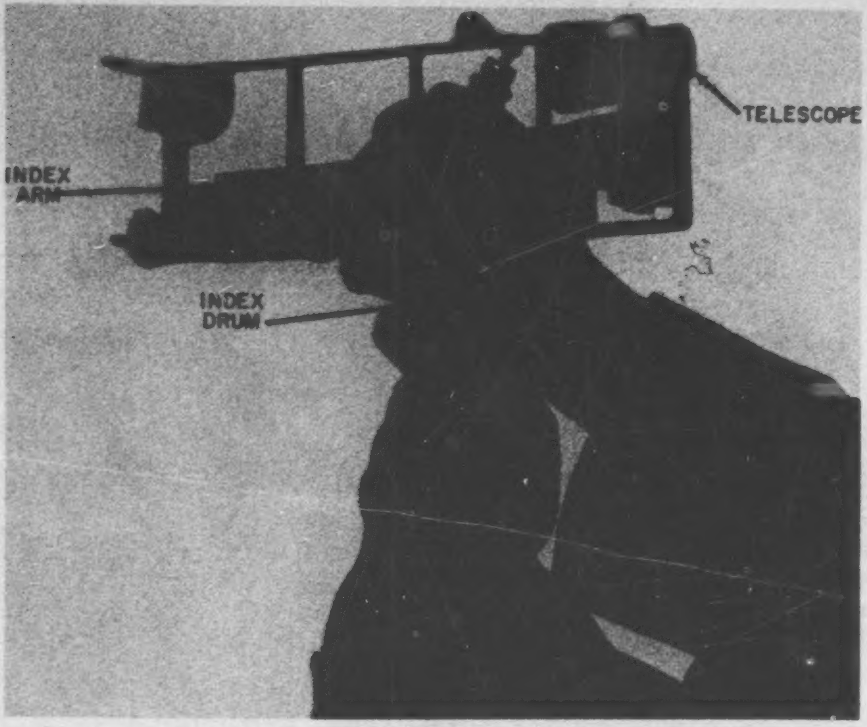
A special type of bearing is the tangent. When a bearing is observed of the right edge of a projection of land, the bearing is a right tangent. Similarly, a bearing on the left edge of a projection of land, as viewed by the observer, is a left tangent. A tangent provides an accurate line of position if the point of land is sufficiently abrupt to provide a definite point for measurement; it is inaccurate when the slope is so gradual that the point for measurement moves horizontally with the rise and fall of the tide.

Distance Arcs

A distance arc is a circular line of position. When the distance from an observer to a landmark is known, the observer's position is on the circle, with the landmark as center, having a radius equal to the measured distance. The entire circle need not be drawn because in practice the navigator normally knows his position near enough that drawing an arc of a circle suffices. The arc is labeled with the time above expressed in four digits. The distance to a landmark may be measured by using radar, stadimeter, or sextant, in conjunction with table 9 of the American Practical Navigator.

The stadimeter is used most frequently to measure distances from your ship to others in a formation. In piloting, it also is used as a navigational instrument to ascertain distance to some navigational aid as, for example, when a ship's position is being determined by bearing and distance of a fixed object of known height.

Stadimeters are of two types: the Fisk type (figure 10-6) and the Brandon sextant type (figure 10-7). In using either type, the height of the object whose distance is desired must be known, and that height must be between 50 and 200 feet. (Usually, when measuring distances to



58.78.2

Figure 10-6.—Fisk-type stadimeter.

ships, the height used is from the boot topping to the top of the mast or highest radar.) Distances are measured with reasonable accuracy up to 2000 yards. Beyond that range the accuracy of the stadimeter decreases progressively.

Operation of the Fisk-type stadimeter, described here, is typical of the two, inasmuch as operation of the Brandon type varies from the Fisk only in minor details. Say you're trying to get the range to a 120-foot light structure. Move the carriage containing the index drum to the 120-foot mark on the index arm. Sight through the telescope at the light structure. As with the sextant, you will see a direct and a reflected image. Turning the drum causes the reflected image to move up or down relative to the direct image. When the top of the reflected image is in line with the bottom of the direct image, distance in yards may be read directly from the drum.

A stadimater is a delicate instrument and requires the same care given a sextant.

PILOTING RECORD

All bearings, ranges, and soundings used in piloting must be recorded in a bearing record log. To facilitate this recording, the Navy publishes a Standard Bearing Book, OPNAV Form 3530/2, for use by all ships. This record is maintained so that a ship's piloting track can be reconstructed if overlays are destroyed or charts are erased. The bearing record must be kept up to date and accurate and must contain all the information used to obtain each fix, including time, name of navigational aid on which bearing or range was taken, bearing or range, and depth of water.

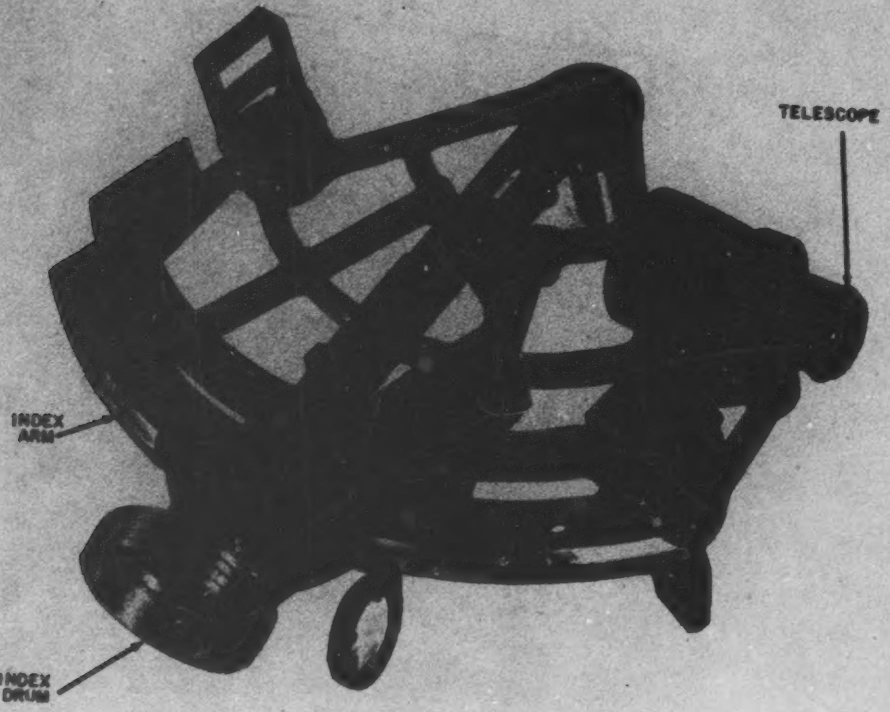


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Figure 10-7.—Brandon sextant-type stadimeter.

In the appropriate spaces on each page of the Standard Bearing Book (figure 10-8) is entered the ship's location and the gyro error. Column 1 contains the date as the first entry. Times are entered chronologically under the date. When the date changes, the new date may be entered on a separate line of the same column.

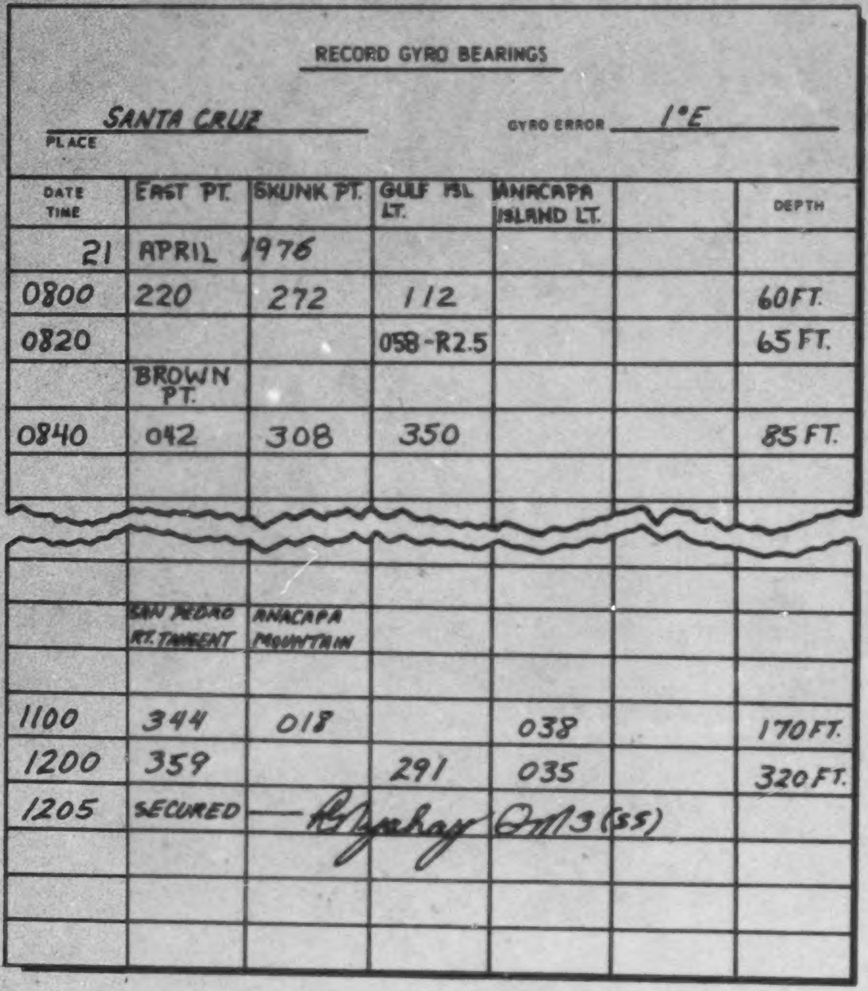
Columns 2 through 6 are headed by the name(s) or other clear identification of the object(s) used to obtain the line of position. Bearings are recorded under the name of each of these navigational aids. Bearings or ranges are placed alongside the appropriate times. All bearings are visual (by gyrocompass) unless otherwise indicated. Radar bearings and ranges must be identified by suitable notation.

In the final column, depth under the keel (as indicated by the echo sounder) is recorded alongside each time.

As with other logs and records, no erasures are permitted in the Standard Bearing Book. A single line must be drawn through errors (so that the entry is still legible); the correct entry is made alongside it. Upon being relieved or secured, the bearing recorder must sign his name across the line immediately below the last piloting entry.

FIXES

A fix is defined as the point of intersection of two or more simultaneously obtained lines of position. The symbol for a fix is a small circle around the point of intersection. For better identification, it is labeled with time expressed in four digits. Fixes may be obtained by means of the following combinations of lines of



RECORD GYRO BEARINGS

PLACE SANTA CRUZ

GYRO ERROR 1°E

DATE TIME	EAST PT.	SKUNK PT.	GULF ISL LT.	ANACAPA ISLAND LT.		DEPTH
21	APRIL	1976				
0800	220	272	112			60 FT.
0820			058-R2.5			65 FT.
	BROWN PT.					
0840	042	308	350			85 FT.
	SAN PEDRO PT. TANGENT	ANACAPA MOUNTAIN				
1100	344	018		038		170 FT.
1200	359		291	035		320 FT.
1205	SECURED	—		QM3 (SS)		

69.142

Figure 10-8.–Standard Bearing Book.

position, of which many types are seen in figure 10-9.

(a) A line of bearing and a distance arc.
(b) Two or more lines of bearing.
(c) Two or more distance arcs.
(d) Two or more ranges.
(e) A range and a line of bearing.
(f) A range and a distance arc.

Because two circles may intersect at two points, two distance arcs used to obtain a fix are somewhat undesirable. In making his choice between two points of intersection, however, a navigator may consider an approximate bearing, a sounding, or his DR position.

When a distance arc of one landmark is used with a bearing of a different landmark, the navigator may again be faced with the problem of choosing between two points of intersection.

Navigation plotting symbols and their meanings are shown in figure 10-10. When these symbols are used, it is not necessary to label the

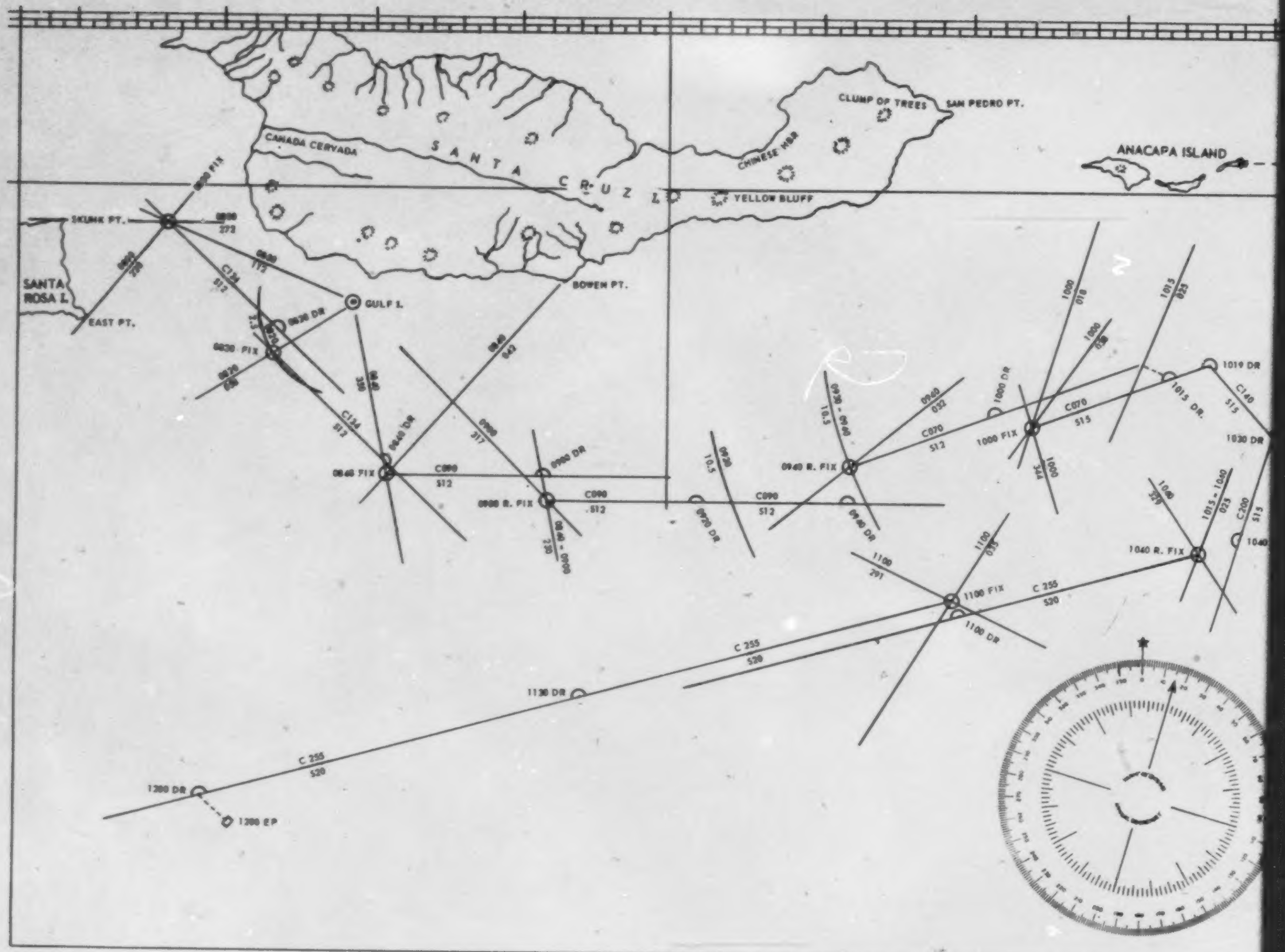

SANTA CRUZ I.
CANADA CERVADA
CLUMP OF TREES
SAN PEDRO PT.
CHINESE HBR
YELLOW BLUFF
ANACAPA ISLAND
SKUNK PT.
SANTA ROSA I.
EAST PT.
GULF I.
BOWEN PT.
0800 FIX
0820 FIX
0820 DR
0840 FIX
0840 DR
0900 R. FIX
0900 DR
0920 DR
0940 R. FIX
0940 DR
1000 FIX
1000 DR
1015 DR
1019 DR
1030 DR
1040 R. FIX
1040
1100 FIX
1100 DR
1130 DR
1200 DR
1200 EP
C134 S12
C090 S12
C070 S12
C070 S15
C140 S15
C200 S15
C 255 S20

Figure 10-9.—Piloting plot

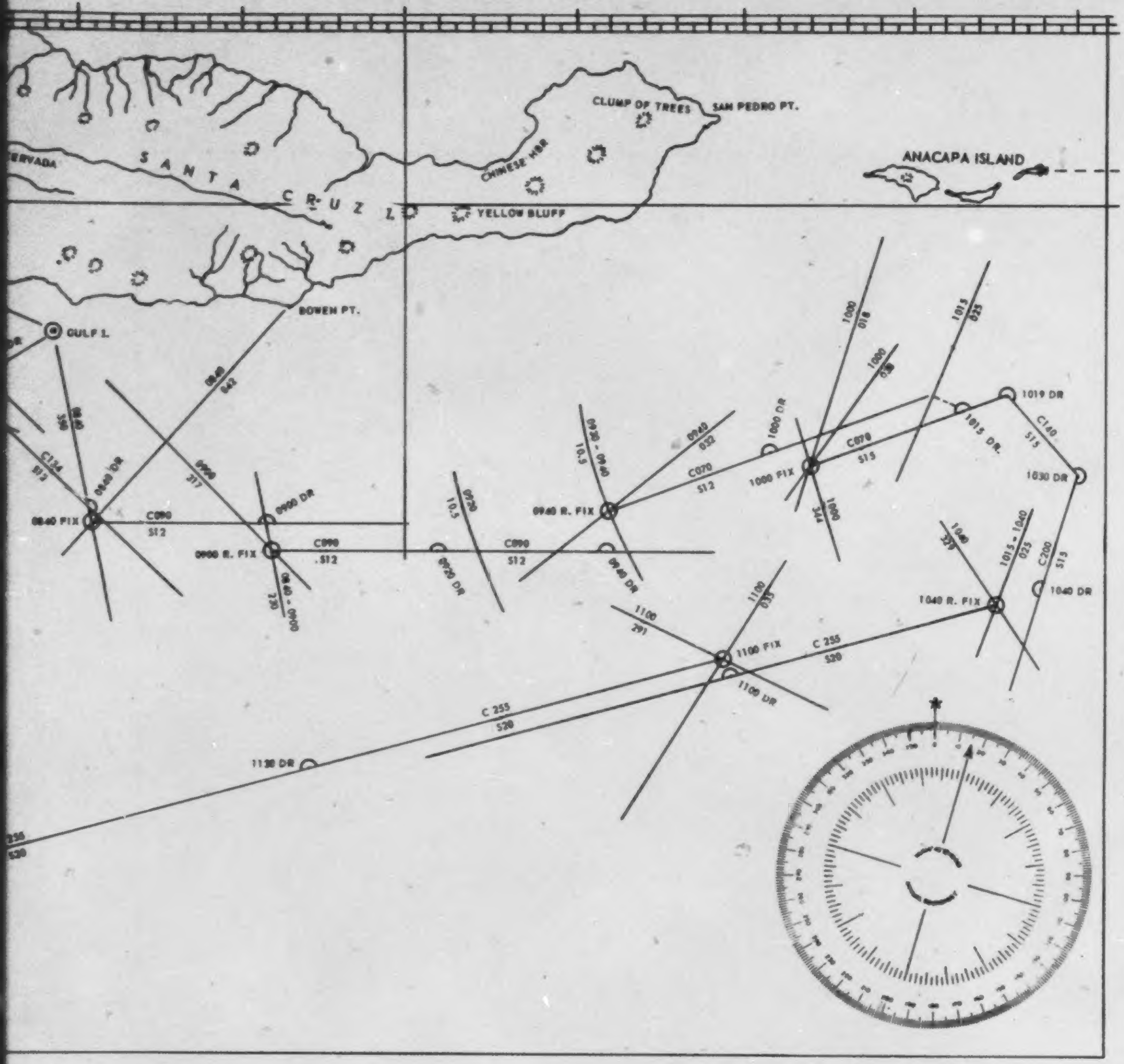

CLUMP OF TREES
SAN PEDRO PT.
ANACAPA ISLAND
SANTA CRUZ I.
CHINESE HBR
YELLOW BLUFF
BOWEN PT.
GULF I.
0840 FIX
0840 DR
C134
S12
0840
042
0900
317
C090
S12
0900 DR
0900 R. FIX
0840 - 0900
10.5
0920
0920 DR
0930 - 0940
0940 R. FIX
0940
052
0940 DR
C070
1000 DR
1000
018
1000 FIX
C070
S15
1000
344
1015
025
1019 DR
1015 DR.
C140
S15
1030 DR
1040
1015 - 1040
025
C200
S15
1040 DR
1040 R. FIX
1100
035
1100
291
1100 FIX
C 255
S20
1100 DR
1130 DR

Figure 10-9.—Piloting plot

69.143

SYMBOL	DESCRIPTIVE LABEL	MEANING
⊙	FIX	AN ACCURATE POSITION DETERMINED WITHOUT REFERENCE TO ANY PREVIOUS POSITION. ESTABLISHED BY ELECTRONIC, VISUAL, OR CELESTIAL OBSERVATIONS.
⌓	DR	DEAD RECKON POSITION. ADVANCED FROM A PREVIOUS KNOWN POSITION OR FIX. COURSE AND SPEED ARE RECKONED WITHOUT ALLOWANCE FOR WIND OR CURRENT.
⊡	EP	ESTIMATED POSITION. IS THE MOST PROBABLE POSITION OF A VESSEL, DETERMINED FROM DATA OF QUESTIONABLE ACCURACY, SUCH AS APPLYING ESTIMATED CURRENT AND WIND CORRECTIONS TO A DR POSITION.

69.149

Figure 10-10.—Plotting symbols.

position (except for time) since a glance tells what type of position is indicated. Any simple, clear, logical, unambiguous system of labels is suitable. Due to various labeling systems in the Navy, your navigator will be the authority on which symbols to use.

SELECTING LANDMARKS

In selecting landmarks for use in obtaining lines of position (LOPS), two considerations enter the problem: angle of intersection and number of objects.

Two lines of position crossing at nearly right angles will result in a fix with a small amount of error as compared to two lines of position separated by less than a 30° spread. If a small unknown compass error exists in both examples, or if a slight error is made in reading the bearings, the resulting discrepancy will be less in a fix produced by widely separated lines of position than when a fix is obtained from lines of position separated by only a few degrees.

If only two landmarks are used, an error in observation or identification may not be apparent. By obtaining three or more lines of position, each LOP acts as a check. If all LOPs cross in a pinpoint or form a small triangle, the fix may be considered reliable. Where three lines of position are used, a spread of 120° would result in optimum accuracy.

Sometimes a navigator has no choice in landmarks, their number, or spread. He then must use whatever reference marks are available, no matter how undesirable. In evaluating his fix, the number of landmarks and their spread should receive consideration. When three lines of position cross, forming a triangle, it is difficult to determine whether the triangle is the result of a compass error or an erroneous LOP. Intersection of four lines of position usually indicates which LOP is in error.

COMPASS ERROR IN PLOTTED FIX

When lines of position cross to form a small triangle, the fix is considered to be the center of the triangle, at a point determined visually. If the size of the triangle appears significantly large, then it is possible that the compass has an error, and the ship's actual location may be outside the triangle.

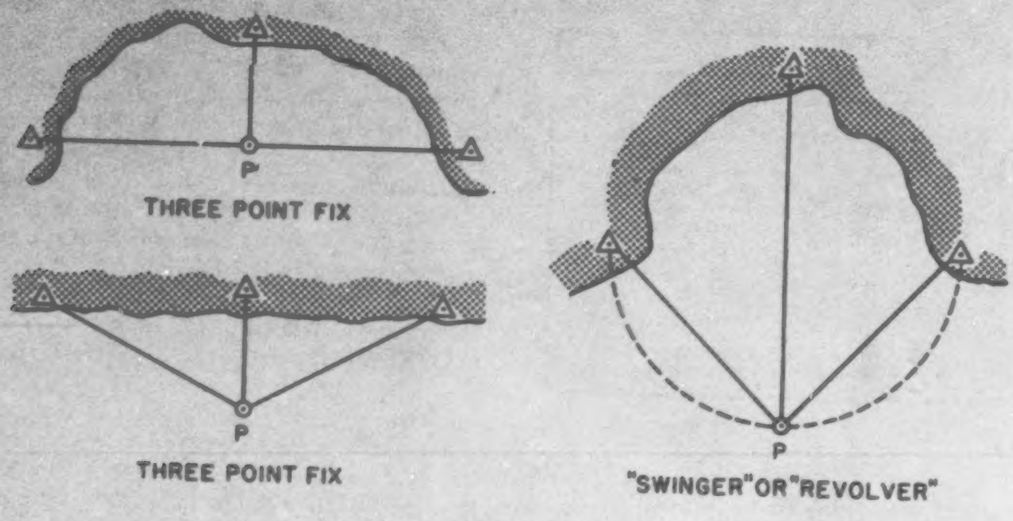
To eliminate the compass error from the fixes, assume an error; then, by successive trials, and assumptions, determine the actual error. If the assumed error is labeled improperly (east or west), the triangle will plot larger. If the error proves to be labeled properly but the triangle still exists, although reduced in size, the navigator on the second trial should assume a larger error in the same direction.

HORIZONTAL SEXTANT ANGLES

In piloting, the most accurate fixes may be obtained by measuring the horizontal angles between three fixed objects whose exact locations are known.

By use of a sextant, which will be discussed in detail in chapter 12, horizontal angles are measured between the object in the middle and the one on either side.

A point to bear in mind is that this method should not be used when the three objects are on a circle whose arc passes through the observer. (See figure 10-11.) Such situations are known as "swingers" or "revolvers." To avoid swingers or revolvers, objects selected should lie in a straight line. When this selection is impracticable, the object in the middle should be nearer the observer than the other two, or the



69.144

Figure 10-11.—Horizontal sextant angles.

angle between the middle object and the two end ones should approach or exceed 180°.

Horizontal sextant angles should be taken as nearly simultaneously as possible, preferably by two people on a predetermined signal. The angles are then set on a three-arm protractor. The protractor arms are then aligned to the objects on the chart, and the observer's location is the focal point of the three arms.

The three-arm protractor is a device of metal or rigid plastic, and has one fixed and two movable arms. (See figure 10-12.) The fixed (center) arm is secured to (or is part of) a graduated circle. The other two arms, fitted with clamping devices, pivot around this circle. The left and right arms may be set to form any angle with the middle arm. All arms have a common vertex. To determine an observer's exact location, the three-arm protractor may be aligned to the beacons on the chart, as seen in the illustration.

RUNNING FIX

So far we've talked about methods for obtaining a definite fix by piloting. Whether obtained by bearing and distance of a single object or by cross bearings of two or more objects, the lines of position are located exactly. Their intersection, consequently, is the ship's location at the time the bearings were taken.

A running fix, on the other hand, is what you might call a dead-reckoning fix, because the location of one of the lines of position is determined by dead-reckoning calculation of the ship's direction and distance traveled during an interval. The most common example of a running fix is a situation where a line of position obtained at a certain time is advanced. Figure 10-13 shows how a line of position is advanced. At 1500 the ship took a bearing of 245° on light E. Since then she has run for 20 minutes at 12 knots on course 012°. Twenty minutes at 12 knots means that she has run 4 nautical miles. This distance is measured to scale along the course line in the direction traveled, and the new line of position is drawn at this point parallel to the old one. The new line of position is labeled 1500–1520 to show that it is a line of position advanced the amount of the run in that interval. At 1500 the ship was somewhere along the 1500 line of position. At 1520 she is somewhere near a point on the 1500–1520 line. The exact spot depends on how accurately the direction and distance traveled are represented by the measured distance along the course line.

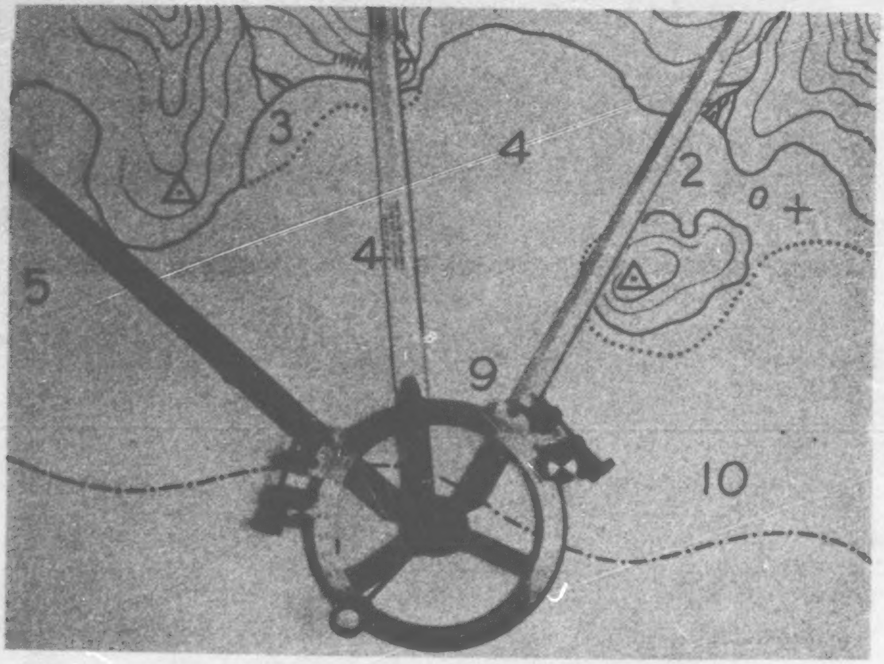


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Figure 10-12.–Three-arm protractor.

You may wonder why a ship would advance a line of position in the manner described here and illustrated in figure 10-13. By way of explanation, suppose that another object is farther up the coast from light E. The object is shown on the chart but cannot be seen from the ship until she arrives at a point somewhere on the 1500–1520 line of position. Intersection of a line of position obtained from a bearing on this object with the 1500–1520 line locates a running fix (a running fix, remember–not a fix). The running fix is labeled "1520 R. fix."

In chapter 12 you will see how a line of position, obtained by observing a single heavenly body, may be advanced to form a running fix by intersection with another line obtained by later observation of the same celestial body. A similar running fix can be obtained in piloting by taking two bearings on the same object, with an interval between them.The Quartermaster 1 & C training course tells how to solve this type of running fix by referring to tables. For the QM 3 or 2 this course is confined to a description of the simplest and most common method of getting a running fix by two bearings on the same object. The method is called doubling the angle, or bow and beam bearings.

Bow and Beam Bearings

In all applications of the two-bearing principle, the basic doctrine can be stated as follows: The distance a ship runs on the same course to double the angle of bearing of an object on her bow equals her distance away from the object at the time of the second bearing.

You don't really need to know why the basic doctrine is true, but a knowledge of trigonometry will give you the answer readily. The most common and convenient application of this principle is with bow and beam bearings. Figure 10-14 illustrates how it works. A ship starts to determine her run from the time the

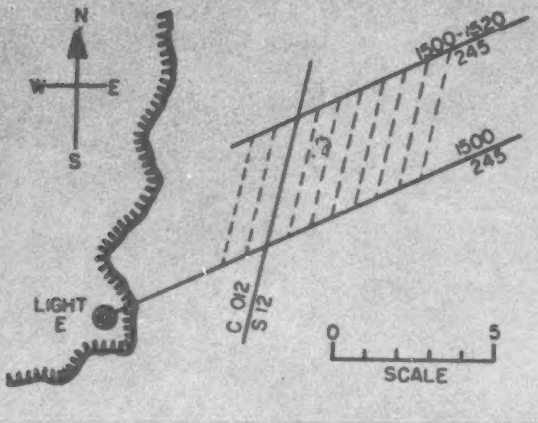

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Figure 10-13.—Advancing line of position.

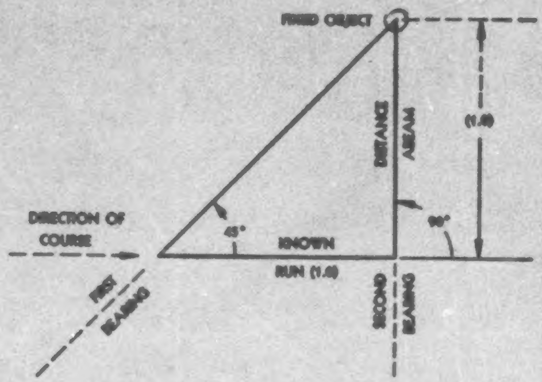

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Figure 10-14.—Bow and beam bearings.

fixed object shown bears 315° relative, which is 45° on her port bow. By the time the object is 270° relative (90° from the bow, or abeam), she has run 1.0 nautical mile. At the time of the second bearing the object is also 1.0 nautical mile distant on the beam. The navigator now is able to locate a running fix by bearing and distance of a single object. Why is it called a running fix? It is a running fix because the navigator must calculate by DR methods the direction and distance run between bearings.

Other special situations of the two-bearing principle include combinations of angles. They are taken up in Quartermaster 1 & C, which also describes the use of tables that make it unnecessary to steam all the distance required to double the angle.

PILOTING BY SOUNDINGS

A position obtained by soundings usually is approximate. Accuracy of this type of position depends on (1) how completely and accurately depths are indicated on the chart and (2) the irregularity of the depths. It is impossible to obtain a position by soundings if the ship is located in an area where depth is uniform throughout. In practice, position by soundings ordinarily serves as a check on a fix taken by some other means.

Before going into the soundings method, let's talk about the ship's depth-finding gear. You learned about the hand lead from the Seaman training course. The hand lead is the most accurate means for obtaining soundings. It usually is used when water is sufficiently shallow and the ship's speed is slow enough to make it practicable.

Before the invention of the depth finder (described later), offshore soundings in water too deep for a hand lead were taken by sounding machine. The machine consisted of a hand-operated reel on which was wound a long length of fine wire. A heavy lead was fastened at the end of the wire. Just above the lead was a metal tube into which was inserted a colored glass sounding tube. The interior of the glass tube changed color to an extent governed by the depth reached by the lead. Sounding machines are now obsolete (much to the satisfaction of any man who ever had to assist at winding in a half mile or so of wire).

SONIC DEPTH FINDER

Modern ships are equipped with depth sounders whose principle of operation is based on the scientific fact that sound travels through saltwater at about 4800 feet per second. A depth finder sends out a signal, which bounces off the ocean floor and returns to the ship as an echo. Obviously, half the time in seconds required for the sound to make the round trip, multiplied by 4800, is the distance (in feet) to the bottom.

AN/UQN-1 Depth Sounder

The type of sounding equipment discussed in this chapter is the AN/UQN-1. (See figure 10-15.) In using this equipment, the depth sounder operator must make certain choices in each of the following conditions.

1. Equipment mode: Standby (ready to operate) or operating.
2. Recorder range: 600 feet, 600 fathoms, or 6000 fathoms.
3. Indicator range: 100 feet or 100 fathoms.
4. Pinging mode: Automatic (periodic) or single ping (hand-triggering).

In making his choices, the depth sounder operator must bear in mind the following limitations of the equipment:

1. For best results, the operator should change scales when the depth warrants although one scale could be used for most depths. A depth of 300 feet, for example, can be recorded on the 6000-fathom scale; it also can be measured on the 600-fathom scale; but the most accurate reading is obtained on the 600-foot scale. On the other hand, when the echo mark approaches the lower edge of the recording paper, a depth has been reached where the next higher scale should be selected.
2. The operator must observe the visual paper warning given through the recording paper roll. A warning light is visible through slots in the paper within 5 feet of the end of the roll.
3. The depth sounder, when used in extremely shallow water, cannot always be adjudged accurate but must be checked constantly by use of the hand lead.
4. As with some other electronic equipment, inaccuracies or malfunctioning of the depth sounder may not readily be discernible. Because completely reliable and accurate soundings are essential, a simple check of the accuracy of the depth sounder has been devised. Following is a description of this check.

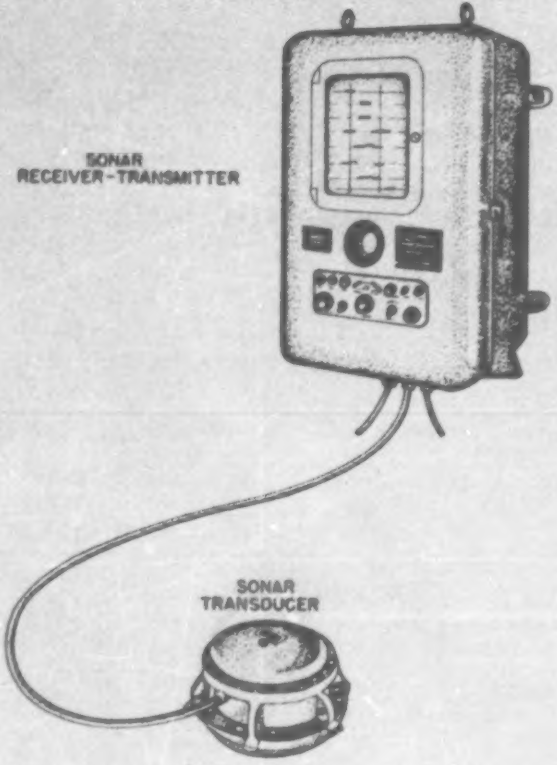

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Figure 10-15.—Depth-sounding sonar AN/UQN-1.

Flash count: When the power supply frequency that operates the depth sounder is not constant, the readings obtained on the recorder are inaccurate. To check for this error, set the recorder on the 6000-fathom range and, with an accurate stopwatch, measure the time for the stylus to travel from 0 to 6000 fathoms. Over a period of five readings, average time should be 10 seconds. If this average time is not obtained, the ship's power supply frequency to the depth sounder should be adjusted to 60 Hertz to remedy the inaccuracy

OPERATING AN/UQN-1—Following is a summary for operating the AN/UQN-1 depth sounding sonar.

1. Turn on power switch.
2. Set depth range and choose either INDICATOR or RECORDER operation on range switch.
3. Select AUTOMATIC (periodic) or SINGLE PING on ping switch.
4. Adjust GAIN CONTROL for suitable marking.

REPLACING CHART PAPER—The following steps should be observed when replacing chart paper on the AN/UQN-1 sounding equipment.

1. Secure power at source; open cabinet door.
2. Release roller-release thrumbscrews at the top and bottom of takeup spool on left side of recorder (containing used recording paper), and swing out the roller.
3. Remove empty spool from right side.
4. Trim paper end of new roll to a V-shape.
5. Install new roll of chart paper on right side of recorder and the used spool (or new spindle) on the left side.
6. Pull paper from right-hand roll across the face of recorder, ruled side facing out. Slip the chart up and under range styluses.
7. Tuck cut edge of paper from right spool into slot of the left spool and roll up a few turns, by hand, with the chart side facing out.

8. Reset drive roller (takeup roller) and tighten securing screws.

9. Close cabinet door and turn on power. You are now ready to record soundings.

MARKING CHART RECORDING PAPER—The chart (figure 10-16) is a specially treated paper on which depth recordings are made. When a new roll of recorder paper is installed in the depth sounder, specific data must be written on it.

1. Ship's name. Place ship's name at the beginning and end of each roll of recording paper or portion thereof.
2. Date. The date is to be annotated once each day at 1200 and when starting and stopping depth sounder.
3. Time. The event marker should be activated at the beginning of the chart paper, at least once each watch thereafter, and at the end of the chart paper.
4. Time Zones. Greenwich mean time (GMT) should be used if practicable. In the event local zone times are used, annotate chart paper whenever clocks are reset and identify zone time in use.
5. Phase or Scale Changes. Clearly label all depth phase (or depth scale) changes and the exact time they occur. Annotate the upper and lower limits of chart paper if necessary.

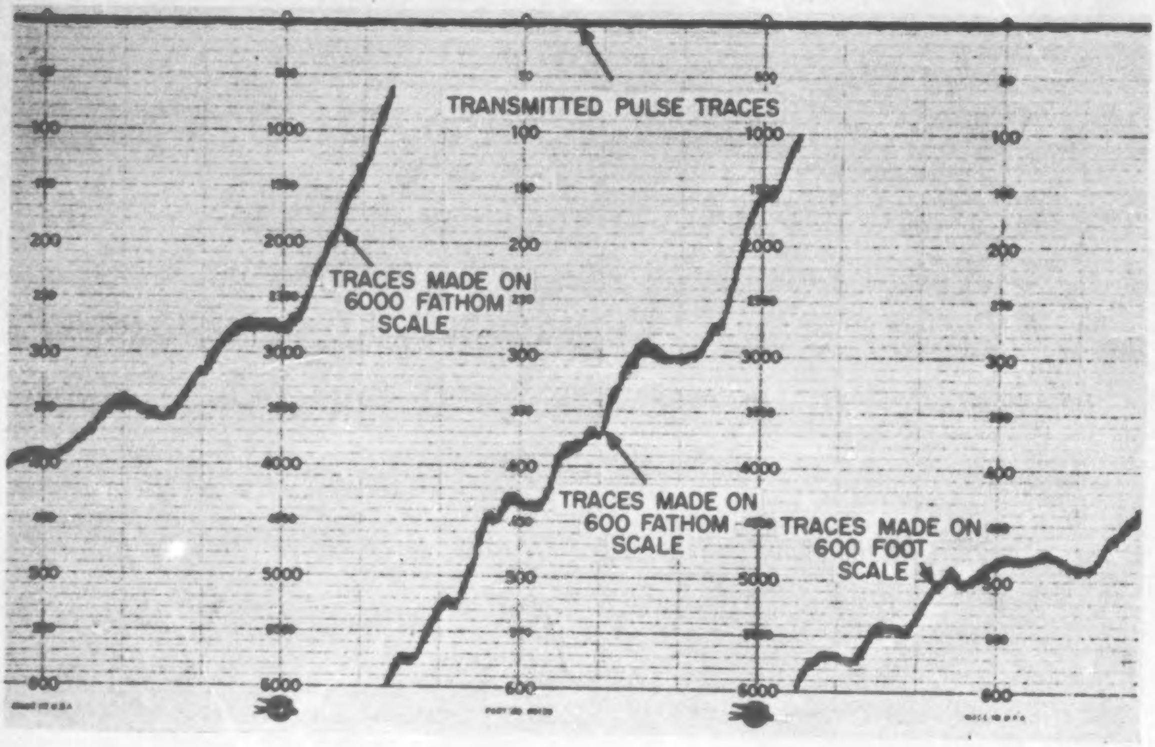
POSITION BY SOUNDINGS

Suppose you have only one spot on or near your DR track where water depth is 6 fathoms, and the depth over the rest of the area for miles around is 20 fathoms. If you heave the lead and record 6 fathoms, you can be certain you are located at the one point where a 6-fathom depth was shown on the chart.

Piloting by soundings is not as simple as that of course, but the supposition gives you an idea of the principle involved. What you really do is get a contour of the bottom you are passing over, and try to match it up with a similar contour shown by depth figures on the chart. One of the best methods is to proceed as follows.

Draw a straight line on a piece of transparent paper or plastic. Calculate how far apart your soundings will be (in other words, the length of the ship's run between soundings), and mark off distances on the line to the scale of the chart. Alongside the mark representing each sounding, record the depth obtained at that sounding. The line so obtained represents ship's course. The line of soundings recorded on the overlay should fit the depth marks on the chart somewhere near you DR track. If it makes an accurate fit, it probably is a close approximation of the course the ship actually is making good.

The continuing need for naval and maritime operations throughout the world makes it increasingly important that every effort be made



62.10

Figure 10-16.—Depth recording showing steady decrease in depth.

to collect accurate oceanographic and related data regarding various oceanic areas. Oceanographic survey ships of the Navy are engaged continually in collecting this information, which includes, in part, the determination of water depth of the oceans, seas, and straits of the world. When oceanographic survey operations are undertaken, use of the depth finder is more intensified than during normal operations. Consequently, more exacting observations must be obtained and recorded.

CHAPTER 11

ELECTRONIC NAVIGATION

Basically, electronic navigation is a form of piloting. Piloting, you recall, is that branch of navigation in which a ship's position is obtained by referring to visible objects on the Earth whose locations are known. This reference usually consists of bearing and distance of a single object, cross bearings on two or more objects, or two bearings on the same object with an interval between them, as you saw in the last chapter.

Position is determined in electronic navigation in practically the same way that it is in piloting, but there is this important difference: The objects by which a ship's position is determined need not be visible from the ship. Instead, bearings (and sometimes ranges) of the objects are obtained by electronic means, usually in the form of radio waves.

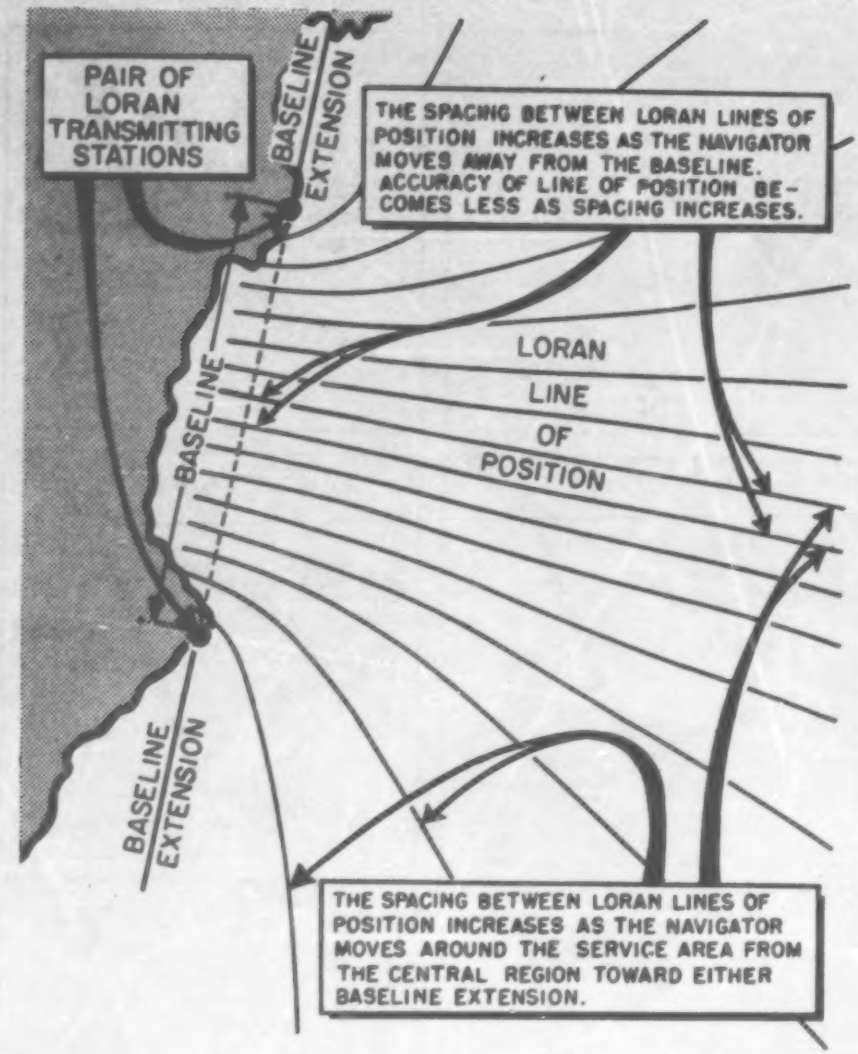
The advantages of piloting by radio are obvious. A ship's position may be fixed electronically in fog or thick weather that otherwise would make it impossible to obtain visual bearings. It may be determined electronically from stations located far beyond the range of even clear-weather visibility. Electronic navigation, invaluable though it may be as an aid to the navigator, depends on the performance of manmade apparatus, which are always subject to failure. Consequently, electronic navigation supplements but does not supplant the tried and true methods of navigation.

LORAN-A

Loran (derived from the underlined letters of the term long range navigation) enables a navigator to determine his ship's position by means of radio signals broadcast by stations of known position. A loran fix is determined from the intersection of lines of position obtained by reference to shore stations whose locations are known. In loran a line of position is located by obtaining the difference in time of arrival of signals sent out by each of a pair of transmitters (broadcasting stations). This time interval is constant when the ship is located anywhere along a previously established loran line of position. To put it another way: When the time interval is a specific amount, the ship must be somewhere on a predetermined loran line of position, which is a locus of all points where the interval between arrival of signals is the same. Unlike lines of position obtained from bearings, loran lines of position gradually become curved as they draw away from the center of the baseline between two transmitting stations. (See figure 11-1.)

HOW LORAN WORKS

Two transmitting stations, a master and a secondary, are required to give you a single line of position by loran. The master station starts the cycle of transmission by sending out a pulse of radio energy that is radiated in all directions. After traveling over the distance between the two transmitting stations, which is known as the baseline, the pulse arrives at the secondary. The time of its arrival there is used by the secondary as a reference for the transmission of its own signal. After the signal is transmitted, the entire cycle is repeated constantly at the same definite time intervals. The loran operating sequence is shown in figure 11-2.


PAIR OF LORAN TRANSMITTING STATIONS
BASELINE EXTENSION
THE SPACING BETWEEN LORAN LINES OF POSITION INCREASES AS THE NAVIGATOR MOVES AWAY FROM THE BASELINE. ACCURACY OF LINE OF POSITION BECOMES LESS AS SPACING INCREASES.
LORAN LINE OF POSITION
BASELINE
BASELINE EXTENSION
THE SPACING BETWEEN LORAN LINES OF POSITION INCREASES AS THE NAVIGATOR MOVES AROUND THE SERVICE AREA FROM THE CENTRAL REGION TOWARD EITHER BASELINE EXTENSION.

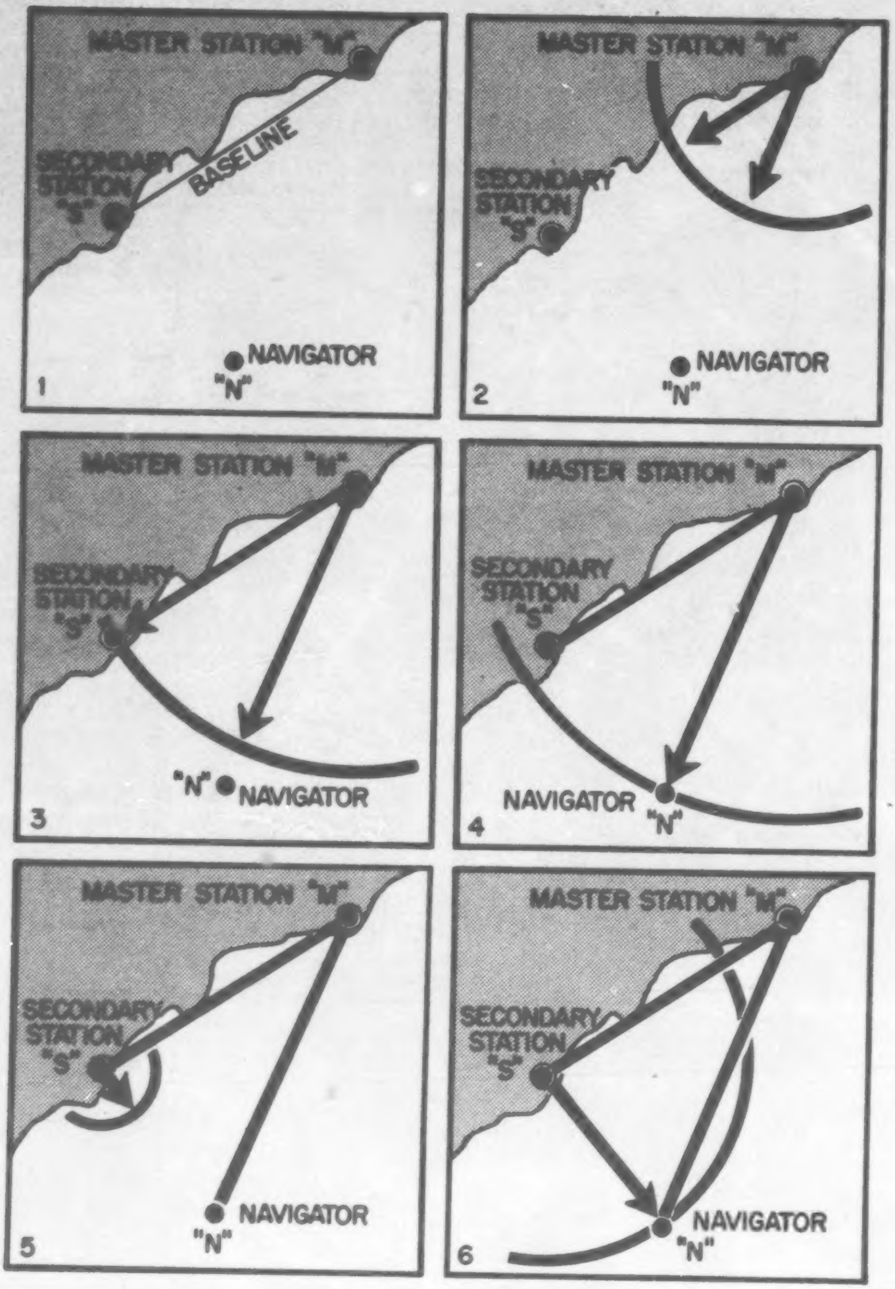
69.45

Figure 11-1.–Loran lines of position are curved.

Because the value of the loran system depends on the accuracy of the timing of the signals transmitted, every precaution is taken to safeguard the functioning of the system. Following are three continuous checks that are applied to ensure a high level of reliability.

1. Continuous guarding of the secondary signal by observations made at the master station.
2. Continuous guarding of the master signal by observations made at the secondary station.
3. Continuous guarding of the complete transmission by monitor stations strategically located with respect to the transmitters.

Loran transmissions can be momentarily faulty owing to many possible causes, such as electrical failure of a part of the equipment, or


MASTER STATION "M"
SECONDARY STATION "S"
BASELINE
NAVIGATOR "N"
1
2
3
4
5
6

69.46

Figure 11-2.—Sequence of operation of loran transmitting stations.

Key to Figure 11-2

Step 1: Navigator at point N, within range of stations M and S, about to receive loran signals.

Step 2: Loran transmission cycle is begun by master station M. Pulse radiates in all directions, travels toward both secondary station and point N.

Step 3: Pulse from master arrives at secondary station but has not yet reached N.

Step 4: Pulse from master arrives at N. Secondary already has received master pulse and is waiting for proper amount of time to elapse before transmitting, to assure correct synchronization with master.

Step 5: After assuring correct synchronization, secondary transmits pulse. Navigator has received pulse from master already.

Step 6: Secondary pulse arrives at N. Because navigator already has received signal from master, loran reading is taken by measuring elapsed time between arrival of master and secondary pulses. After both signals travel throughout their effective range, cycle is repeated.

operating error in manipulation of transmitting controls. Even though these troubles may be minor and of relatively short duration, the navigator should be instantly cognizant of any failure. The transmitting equipment is designed to produce a characteristic, easily recognizable, shift of signals to the right, about 1000 microseconds (μsec), and back at intervals of about 1 second; or, in rare instances, a signal may be turned off and on at short intervals at which time the navigator is warned that the signals must not be used.

Whenever failure is sufficiently serious to interrupt transmission entirely, there is no danger of misinterpretation on the part of the navigator, because reception of an impulse from only one of a pair of stations makes the system inoperable.

RANGE AND RELIABILITY

Making the three continuous checks referred to earlier assures the surface or air navigator that any loran transmissions he receives (except shifting signals) are accurate and reliable.

Under almost any kind of weather conditions, lines of position by loran-A are fully as accurate as those obtained from good celestial observations. Determination of position by loran-A requires only 2 or 3 minutes' time.

Reception of signals is possible at distances from the transmitting stations out to 1400 nautical miles at night, and 700 to 800 nautical miles in the daytime. The reason for the day-night difference in effective range is discussed in the next topic.

The United States Coast Guard operates approximately 39 loran-A transmitting stations throughout the world. Other nations operate approximately 40 more stations. They provide loran service along both coasts of North America, along the great circle courses of the North Atlantic and North Pacific, and in the Central and Southwest Pacific. A considerably larger number of transmitting stations is required for coverage of all the major air and sea traffic routes of the world.

WAVE CHARACTERISTICS AND SIGNAL IDENTIFICATION

The range of loran stations, the type of signal received, and the accuracy of the resulting time difference measurement are affected by the path over which the radio waves travel. The portion of the radio energy which travels, from the transmitters, parallel to the surface of the Earth is known as groundwaves. Another portion of the radio energy travels upward and outward, encounters electrified layers of the atmosphere, and, if conditions are favorable, reflects back to the receiver. These reflections are known as skywaves.

Ground Waves

During the daytime, groundwaves can be expected to reach a range of about 600 or 700 miles. At night, because of atmospheric disturbances, the groundwave range is reduced to 400 or 500 miles. The actual range at which a loran signal may be received depends on many factors, but generally speaking ranges decrease in the tropic zones and increase in the polar zones. Intervening land reduces the range by approximately one third; however, the accuracy of the loran system is unaffected. Ranges vary with the position of the receiver in relation to the transmitters and with the time of day.

Groundwaves are normally steady in shape and size; however, they may vibrate at maximum ranges and their amplitude may vary when the ship rolls or pitches greatly. This condition can readily be identified as the signals vary in time to the rolling and pitching of the ship.

Time differences obtained using groundwaves require no corrections before plotting on a chart or when using the loran publications.

Skywaves

Skywaves are primarily a nighttime signal but may sometimes appear during the daytime. Ranges of skywaves vary but can usually be expected out to about 1200 to 1400 miles. You will find that many skywave signals will form on the scope, but only the first skywave received is usable for navigation (I Hop E). All other skywaves are not reliable for navigation because they are too erratic and no skywave corrections are computed for them. As skywaves are reflected from the ionosphere, the actual amount of miles that these signals travel is considerably greater than the equivalent groundwave. Therefore, all skywaves require a correction. Because all charts and publications are computed on the assumption that all signals received will be groundwaves, the skywave corrections convert skywave time difference readings to equivalent groundwave readings.

The minimum usable skywave range is 250 miles from the transmitters. When closer than that, the skywave corrections can not be accurately computed. When in the area between 250 and 350 miles from the transmitters, caution should be used as only a slight difference between your actual position and your DR position will cause large errors in your skywave corrections.

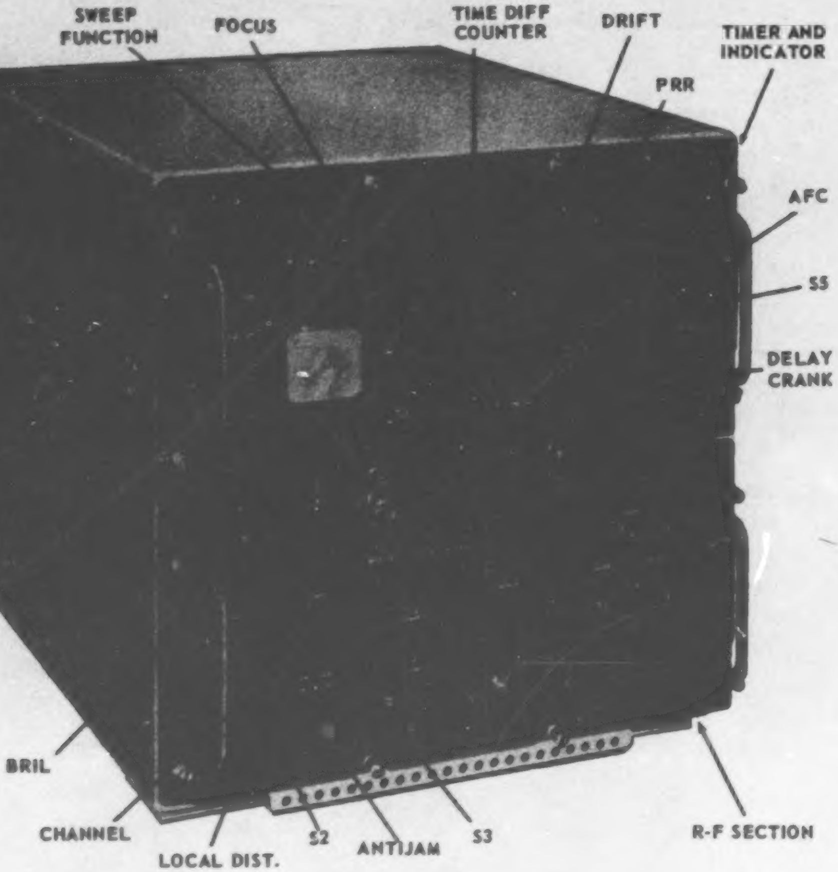
All skywaves may be identified by their inherent characteristics. All skywaves will, if given time, split and/or fade. This condition makes it easy to determine what kind of signals you are receiving. Always match a groundwave to a groundwave or a skywave to a skywave. Keep in mind the ship's position and the time of day. Patience and experience go a long way toward making you a more proficient operator.

SHIPBOARD LORAN EQUIPMENT

Loran equipment used by the navigator aboard a ship or aircraft is known as a receiver-indicator. (See figure 11-3.) The unit consists of a receiver for picking up and amplifying the signals and an indicator that makes the electrical impulses visible. This unit is also a timer by which the navigator can measure the interval in microseconds (millionths of seconds) between times of arrival of the first and second signals from the pair of transmitters.

Figure 11-4 is a presentation of loran timing sequences. A loran time difference is measured by cycling the time base with respect to the transmitted signals until the master and secondary signals appear on the upper (A) and the lower (B) traces of the scope, respectively. Examine the signals on the scope operating on fast sweep and make a fine adjustment until the pulses are matched with respect to time. Time differences are then read directly from a mechanical counter.

The technique for reading the indicator can be learned in less than 1 hour from a qualified operator demonstrating on the scope of an actual receiver-indicator. The result is expressed in microseconds. The time of observations, plus the rate and type of wave used, is always included when the reading is recorded. The rate consists of two figures separated by a letter. The


SWEEP FUNCTION
FOCUS
TIME DIFF COUNTER
DRIFT
TIMER AND INDICATOR
PRR
AFC
S5
DELAY CRANK
BRIL
CHANNEL
LOCAL DIST.
S2
ANTIJAM
S3
R-F SECTION

60.47

Figure 11-3.—Loran receiving set.

first figure indicates frequency; the second, the basic pulse repetition rate (PRR); and the last figure, the specific pulse repetition rate of the signals broadcast by that particular pair of stations. A typical rate is 2L6, which means that this pair of stations operates on frequency channel 2, at low basic recurrence rate, and at the specific pulse repetition rate assigned to stations designated by the number 6. The rate is essential when plotting a line of position by loran. A proper recording of a reading by loran would be 1130:2L6 Tg 2040. This loran reading means that at 1130 a reading of 2040 μsec was obtained by groundwaves (Tg) from the pair of stations whose rate is 2L6.

PLOTTING LORAN LINES OF POSITION

Loran lines of position (LOP) may be plotted by using either charts or tables. A description of each method follows.

Plotting Charts

Figure 11-5 shows part of one of the special charts designed for plotting loran lines of position. You can see how lines of position from the pair of transmitting stations (rates 2L0 and 2L1) are drawn in at intervals of 50 to 100 μsec. To plot a line, it is necessary to draw in only the

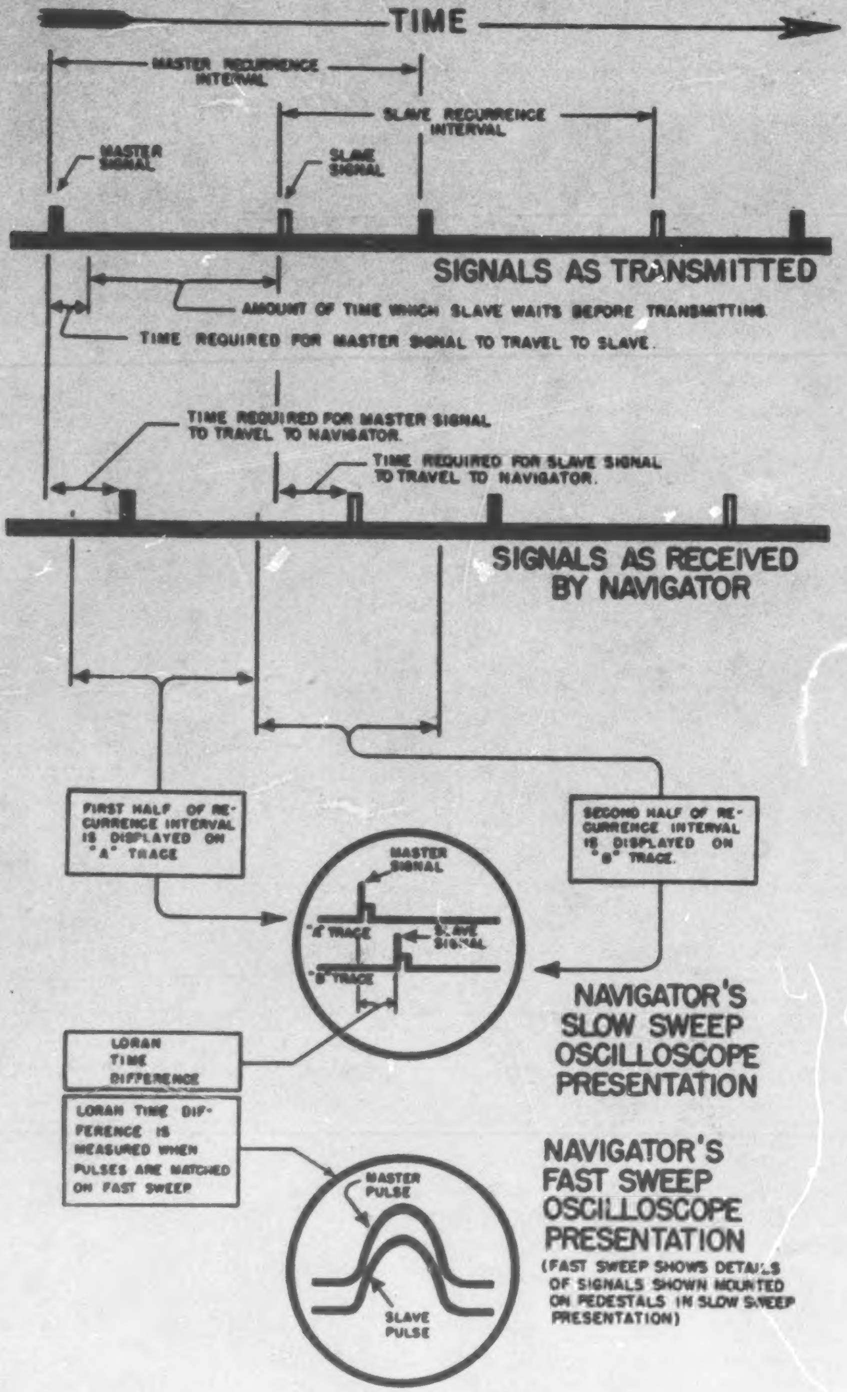
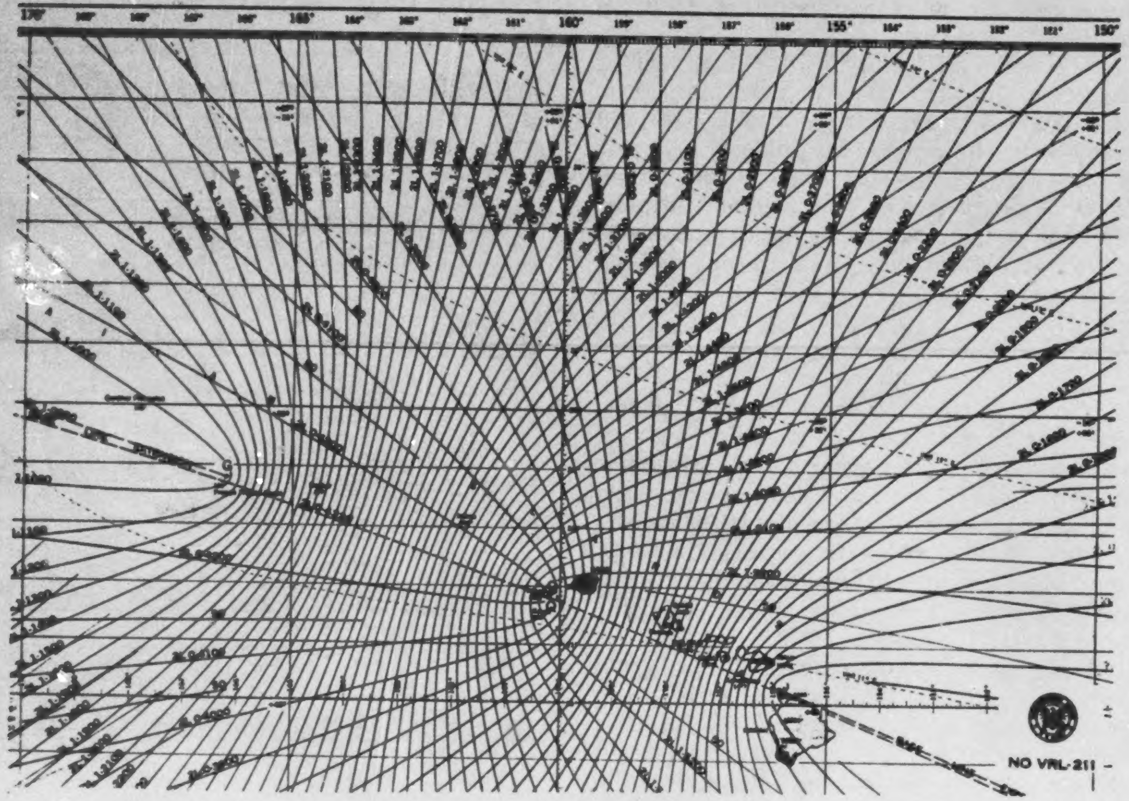

TIME
MASTER RECURRENCE INTERVAL
SLAVE RECURRENCE INTERVAL
MASTER SIGNAL
SLAVE SIGNAL
SIGNALS AS TRANSMITTED
AMOUNT OF TIME WHICH SLAVE WAITS BEFORE TRANSMITTING
TIME REQUIRED FOR MASTER SIGNAL TO TRAVEL TO SLAVE.
TIME REQUIRED FOR MASTER SIGNAL TO TRAVEL TO NAVIGATOR.
TIME REQUIRED FOR SLAVE SIGNAL TO TRAVEL TO NAVIGATOR.
SIGNALS AS RECEIVED BY NAVIGATOR
FIRST HALF OF RECURRENCE INTERVAL IS DISPLAYED ON "A" TRACE
SECOND HALF OF RECURRENCE INTERVAL IS DISPLAYED ON "B" TRACE.
MASTER SIGNAL
"A" TRACE
SLAVE SIGNAL
"B" TRACE
NAVIGATOR'S SLOW SWEEP OSCILLOSCOPE PRESENTATION
LORAN TIME DIFFERENCE
LORAN TIME DIFFERENCE IS MEASURED WHEN PULSES ARE MATCHED ON FAST SWEEP
NAVIGATOR'S FAST SWEEP OSCILLOSCOPE PRESENTATION
(FAST SWEEP SHOWS DETAILS OF SIGNALS SHOWN MOUNTED ON PEDESTALS IN SLOW SWEEP PRESENTATION)
MASTER PULSE
SLAVE PULSE

Figure 11-4.—Loran timing sequences.

60.48



69.49

Figure 11-5.–Part of a loran chart.

portion of it near the DR, interpolating between printed lines as necessary.

Incidentally, lines shown on the charts are for groundwaves (Tg). If skywaves (Ts) are matched, a different reading is obtained, and the skywave corrections appearing at intersections of latitude and longitude lines on the chart are used to compute corrections for DR positions. These computed corrections must be applied to readings before lines are plotted. Air navigators frequently prefer loran plottings by chart because the method is fast and easy to use.

Plotting Tables

Tables (Pub 221 series) are available for plotting loran lines directly on ordinary navigational charts or plotting sheets. The loran tables contain (in tabular form) essentially the same information as plotted on loran charts. Where both tables and charts are available, the choice of which to use lies with the navigator. In some regions the tables may contain lines from rates that are omitted from the charts in order to reduce clutter. Therefore, if readings are obtained for rates but the corresponding lines-of-position are not shown on a particular chart, the tables should be consulted to see if those lines are tabulated there. If so, the lines can be placed on the chart, or the tables can be used for that fix.

Entries are given in the tables for every 15′, 30′, or 1°of latitude or longitude, depending on the amount of curvature of the line. Whether the latitude or the longitude is tabulated depends on the angle the line of position makes with the meridian.

You enter the tables with the loran reading (corrected for skywave, if necessary, from information given at the front of the tables), and either the latitude or the longitude on each side of the DR. From the tables you obtain corresponding values of longitude and latitude, and thus can locate two points. A line drawn between the two points is a segment of your loran LOP.

DISADVANTAGES OF LORAN

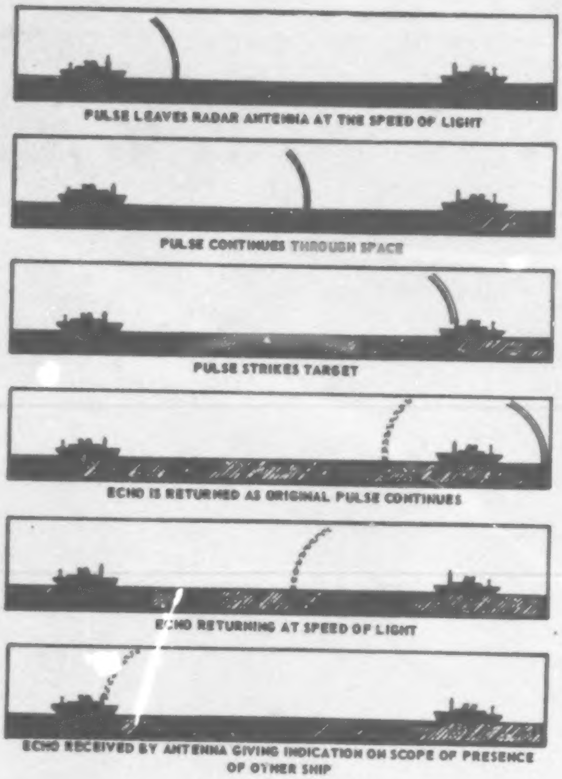
The advantages of loran are sufficient to make the system one of the most valuable electronic aids to navigation yet developed. Nothing made by man is perfect, however, and even loran is subject to certain disadvantages. Although it has proved to be highly reliable, there is always a possibility of failure of either transmitting or receiving equipment. Jamming by an enemy is possible.

Loran coverage still is restricted; that is, many large areas of the world are without any loran coverage at all, particularly the Southern Hemisphere. Within the areas of coverage, readings close to the baseline extension and in the extreme range limit areas must be used with extreme caution because a small error in time difference can cause a "fix" error in miles.

Because of the foregoing reasons, loran is only an aid to the navigator. It does not replace the older methods of navigation.

RADAR

Radar (derived from the underlined letters of the term radio detection and ranging) was developed originally as a means for detecting and ranging on targets in warfare, but it has been developed to the point where it is a valuable electronic navigational aid. Its principle of operation (figure 11-6) is based upon the fact that radio waves are reflected from solid objects. It has the great advantage over loran of not requiring any shore transmitting stations. Radar's chief disadvantage is that its maximum range, for a surface vessel, is limited to slightly more than the line-of-sight of the horizon. Despite its limitations, radar remains a most important navigational aid. A summary of the advantages of radar as a navigational aid follows.


PULSE LEAVES RADAR ANTENNA AT THE SPEED OF LIGHT
PULSE CONTINUES THROUGH SPACE
PULSE STRIKES TARGET
ECHO IS RETURNED AS ORIGINAL PULSE CONTINUES
ECHO RETURNING AT SPEED OF LIGHT
ECHO RECEIVED BY ANTENNA GIVING INDICATION ON SCOPE OF PRESENCE OF OTHER SHIP

69.50

Figure 11-6.—Principle of radar operation.

1. Radar can be used at night and during periods of low visibility when visual means of navigation cannot be employed.

2. A fix can be obtained from a single object.

3. Radar navigation is often more accurate than other means of navigation, especially during periods of reduced visibility.

4. Radar fixes may be obtained rapidly.
5. Radar can be used to locate and track storms.

HOW RADAR WORKS

Basically, radar employs very short electromagnetic waves and utilizes the principle that these waves can be beamed, that they travel in a straight line, and that they will be reflected by any abrupt discontinuity in the medium through which they are transmitted. Because you are interested chiefly in the navigational aspects of radar, only a general description of how radar works is given here.

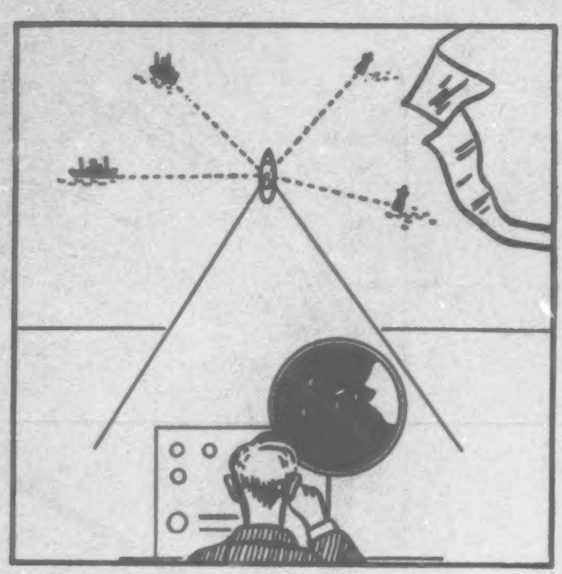
The typical surface radar is made up of five components. They are the transmitter, modulator, antenna, receiver, and indicator. The transmitter consists of a radiofrequency oscillator which sends out electromagnetic waves of energy. The modulator is a device that makes it possible for the waves to be emitted as pulses. The antenna assembly is so designed that it beams the energy at the target, much as a searchlight is beamed. It also can be rotated so as to scan the surrounding area. In the receiver, the reflected radio energy returned from the target is converted into a form that may be presented visually on an indicator or scope.

PLAN POSITION INDICATOR

The PPI scope (figure 11-7) provides a bird's-eye view of the area covered by the radar, with your ship in the center. The sweep originates in the center of the scope and moves to the outside edge. This straight line sweep is synchronized with the radar antenna and rotates 360°. Therefore, the PPI provides bearing and range information. Each time a target is detected it appears as an intensified spot on the scope.

The PPI is designed to enable the navigator to determine the range and bearing of an object, which is one of its chief navigational advantages. The scope can be adjusted to several different range scales to provide greater target detail. Range is measured in yards or nautical miles from the center of the scope to the target indication.

To obtain target position, the PPI is equipped with a bearing cursor and a range strobe. The bearing cursor, like the sweep, appears as a bright line. It can be rotated, manually, through 360°. Bearing information is obtained by rotating the cursor to the center of the target. The target bearing is then read directly from the bearing dial. The range strobe appears as a bright spot riding on the cursor. As the range crank is turned clockwise, the strobe moves out from the center. Range is obtained by placing the strobe on the leading edge (edge closest to the center of the PPI) of the target. The target range is then read directly from the range dials, either in miles or yards.

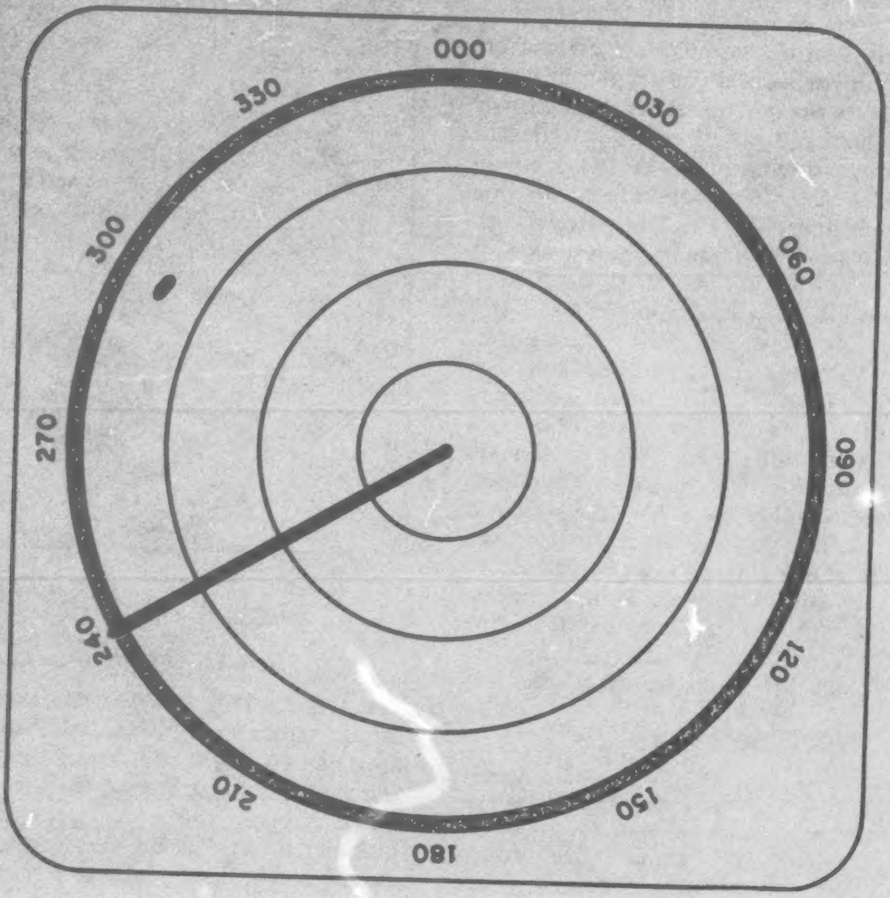


69.51

Figure 11-7.—A PPI presentation.

The bright rings seen in figure 11-8 are range markers or range rings. Range markers can be switched on or off, and their brightness can be controlled as needed. The range indicated by each ring depends, of course, upon the scale used. For instance, if each ring represents 5,000 yards, the outer edge in this illustration is 20,000 yards. The target shown halfway between the third ring and the edge of the scope is at a range of about 17,500 yards and a bearing of 300°.

On gyro-equipped ships (and most ships having radars are so equipped), the radar has a gyro input, and bearings obtained from it are true. If gyro failure occurs, the radar



69.52(69)B

Figure 11-8.—A target and range markers on PPI scope.

presentation automatically reorients to a relative picture and relative bearings may be taken from the PPI.

PILOTING BY RADAR

Subject to the judgment of the navigator, after experience with his equipment, a well-determined position by radar is labeled "fix." A less reliable position is labeled "estimated position" (EP). Because of beam width distortion radar bearings usually are less accurate than are radar ranges. A fix obtained where two or more lines of position are determined by ranges is more accurate than one obtained by bearings alone. Methods of obtaining radar fixes are by (1) range and bearing of a single object, (2) cross bearings, and (3) two or more ranges.

Range and Bearing to a Single Object

Preferably, radar fixes obtained through measuring the range and bearing to a single object should be limited to small, isolated fixed objects which can be identified with reasonable certainty. In many situations, this method may be the only reliable method which can be employed. If possible, the fix should be based upon a radar range and visual gyro bearing because radar bearings are less accurate than visual gyro bearings. A primary advantage of the method is the rapidity with which a fix can be obtained. A disadvantage is that the fix is based upon only two intersecting position lines, a bearing line and a range arc, obtained from observations of the same object. Identification mistakes can lead to disaster. If the fix is based upon a floating aid, it should be treated with considerable caution.

Two or More Bearings

Generally, fixes obtained from radar bearings are less accurate than those obtained from intersecting range arcs. The accuracy of fixing by this method is greater when the center bearings of small, isolated, radar-conspicuous objects can be observed.

Because of the rapidity of the method, the method affords a means for initially determining an approximate position for subsequent use in more reliable identification of objects for fixing by means of two or more ranges.

Fixing by tangent bearings is one of the least accurate methods. The use of tangent bearings with a range measurement can provide a fix of reasonably good accuracy.

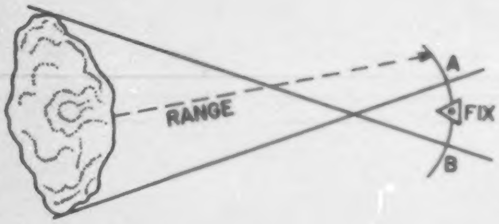
As illustrated in figure 11-9, the tangent bearing lines intersect at a range from the island observed less than the range as measured because of beam width distortion. Right tangent bearings should be decreased by one-half the horizontal beam width. Left tangent bearings should be increased by the same amount. The fix is taken as that point on the range arc midway between the bearing lines.

It is frequently quite difficult to correlate the left and right extremities of the island as charted with the island image on the PPI. Therefore, even with compensation for half of the beam width, the bearing lines usually will not intersect at the range arc.

Two or More Ranges

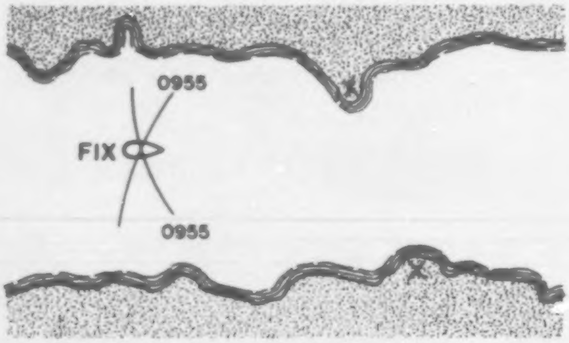
Two or more ranges provide the most accurate radar fix, provided the radar is properly calibrated and range errors are known for each indicator. Radar ranges are reasonably accurate for any range within the maximum limit of the equipment. Figure 11-10 shows how distance circles are intersected to form the fix. Additional ranges afford good checks against improper interpretation of the original points on which the ranges were taken.

Figure 11-11 shows a device that can be constructed easily aboard ship for plotting two ranges. Pivot two transparent plastic arms at a common point, and drill a small hole at the pivot, just large enough for inserting a pencil point. Calibrate the arms to the scale of the chart, with zero range at the pivot. To plot a fix, simply place the plotter on the chart so that the observed range from each target is exactly over



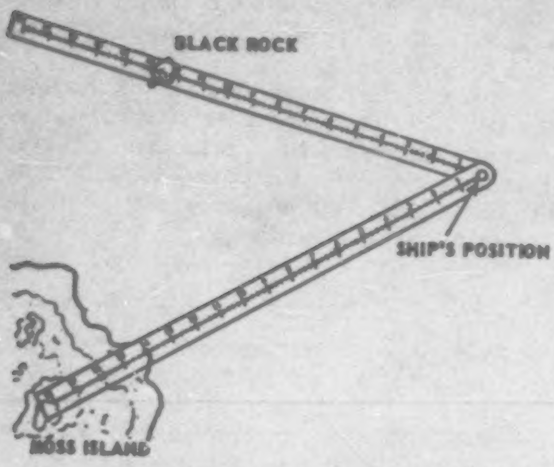
69.53

Figure 11-9.—Tangent bearings and range.



69.61

Figure 11-10.—Radar fix by two ranges.



59.62

Figure 11-11.—Plastic plotter for determining position from ranges.

that target's indication on the chart. The hole in the pivot then will be located at the fix.

NAVIGATIONAL RADAR TARGETS

Small isolated rocks are excellent targets for center bearing and ranges. Because they are well defined, they can be plotted accurately from the exact point of echo. Small islands are also good, but large ones, as you have seen, require tangent bearings instead of center bearings.

Sharp points of land often are used for ranges and for either tangent or center bearings. In ranging on land, you must be certain to plot your range arc from the point that actually produced the radar echo. Sometimes what appears to be a waterline on a radarscope is, in fact, some point inland or possibly a surfline offshore.

Buoys are good for ranges and bearings because, like small rocks, they are well defined and produce sharp echoes. For several reasons, however, buoys may go off their stations. Buoys should not be used for fixing position unless no better quality targets are available.

Offshore lighthouses on rocks or pilings are reliable radar targets. They are also easy to identify. Large charted buildings, tanks, towers, and the like often can be picked up by an experienced operator even though they may be located some distance inland.

When distant mountains are the only objects available, you must bear in mind that it is difficult to get an accurate range from such a large mass. The bearing inaccuracy may also be considerable under such circumstances.

INTERPRETING RADAR INFORMATION

Interpreting radar information requires considerable experience. Even then an operator may not always be able to interpret correctly. Bearing resolution, range resolution, and radar shadows are but three of the problems that hinder radar interpretation.

BEARING RESOLUTION

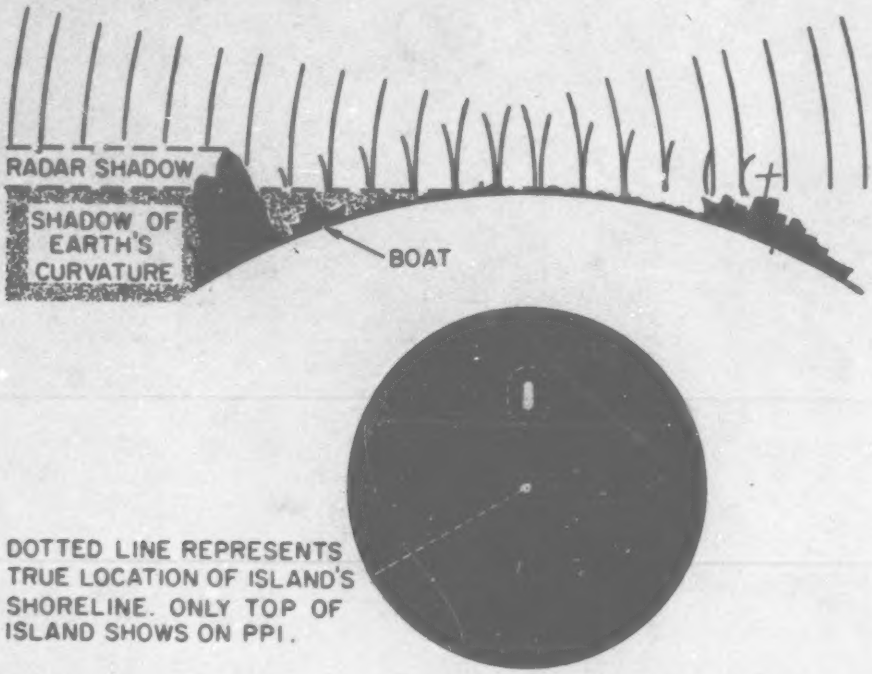
The minimum difference in bearing between two objects at the same range that can be discerned on the scope is called bearing resolution. The radar beam width causes a target to appear larger than it actually is. If two targets are close together and at about the same range, their pips may merge and form a single pip, giving evidence of a larger target. A number of rockpiles and small boats near shore may appear as a straight line, giving a false impression of the shoreline. Bearing resolution can sometimes be improved by reducing the radar receiver gain.

RANGE RESOLUTION

The minimum difference in range between two objects on the same bearing that can be discerned by radar is called range resolution. Two or more objects on the same bearing and at only a slight difference in range may appear on the scope as a single long object. Range resolution can sometimes be improved by reducing the radar receiver gain.

SHADOWS

Echos are not returned from an object that lies behind another object obstructing the radar beam. Radar shadows occur behind prominent


RADAR SHADOW
SHADOW OF EARTH'S CURVATURE
BOAT
DOTTED LINE REPRESENTS TRUE LOCATION OF ISLAND'S SHORELINE. ONLY TOP OF ISLAND SHOWS ON PPI.

69.54

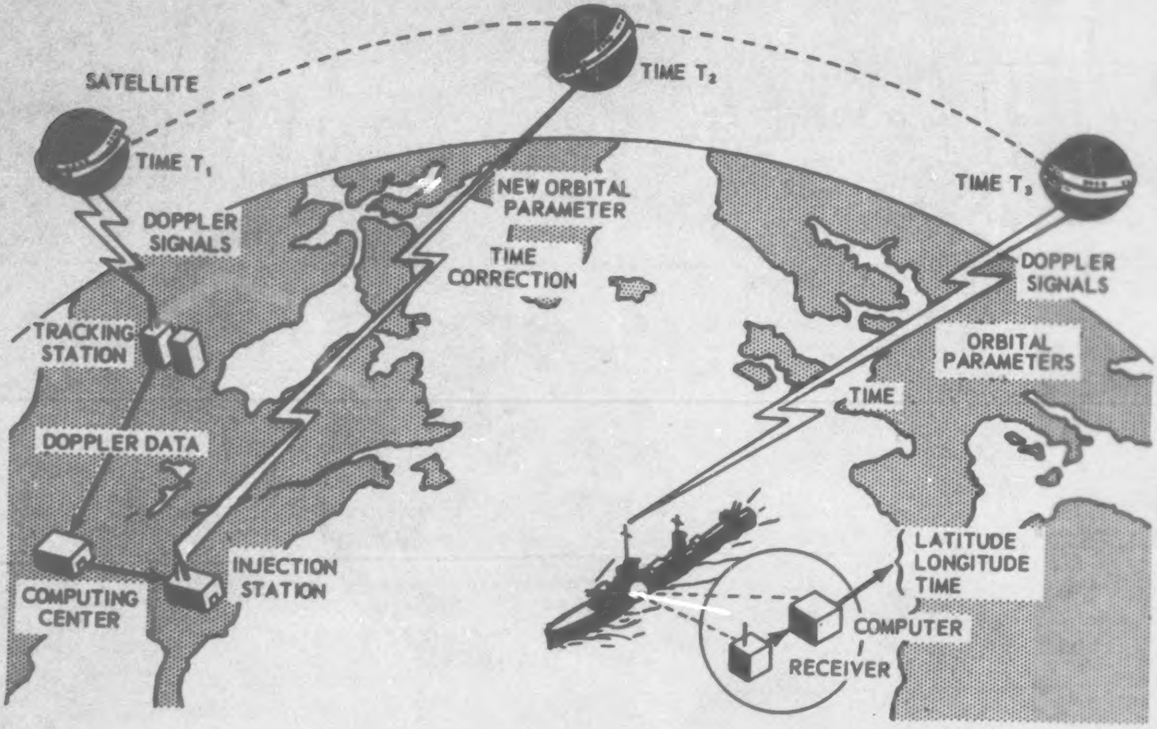
Figure 11-12.–Radar shadow.

objects. Small boats or rocks that lie a considerable distance beyond the horizon cannot be picked up by radar. Figure 11-12 shows a boat that cannot be located by radar because of shadow. In the distance, the radar picks up the top of an island, but the bottom is in the shadow created by the Earth's curvature.

NAVIGATION BY SATELLITES

The navigational satellite system is a global all-weather system. With its use, navigators in ships on or below the ocean surface can obtain a fix to within a fraction of a mile, night or day, in all parts of the world. Although it is usable worldwide, fix information is available only during a satellite pass, which may occur every 45 to 150 minutes, more often at high latitudes than on the Equator. On some occasions satellites may interfere with one another due to the close proximity of their orbits. This is especially true at high latitudes as the satellites are all in polar orbits.

The system operates on the doppler principle. Doppler can best be described by example. Suppose, as you stand at a railroad crossing, a train approaches with its whistle sounding. As the train comes nearer, the pitch of the whistle becomes higher until the train passes you. At this time the pitch drops and, as the train goes off into the distance, the pitch of the whistle gradually grows lower. The change in pitch is called doppler shift. The signal from a satellite approaching and passing over a ship likewise has a change in pitch, or doppler shift. Analysis of the doppler shift enables the navigator to calculate his position relative to the satellite. The position of the satellite is radioed from the satellite so that the navigator can take the doppler information, along with the satellite position information, and determine his ship's position.


SATELLITE
TIME T₁
TIME T₂
TIME T₃
DOPPLER SIGNALS
NEW ORBITAL PARAMETER
TIME CORRECTION
DOPPLER SIGNALS
ORBITAL PARAMETERS
TIME
TRACKING STATION
DOPPLER DATA
COMPUTING CENTER
INJECTION STATION
LATITUDE
LONGITUDE
TIME
COMPUTER
RECEIVER

69.55

Figure 11-13.—Navigational satellite system.

The navigational satellite system requires five groups of equipment: several satellites, tracking stations, a computing center, an injection station, and shipboard navigational equipment. Following is a brief explanation of how the system works. (Referring to figure 11-13 may help you understand the system.)

As each of the navigational satellites orbits the Earth, the tracking stations receive and record the doppler shifts radiated by each satellite as it passes within receiving range.

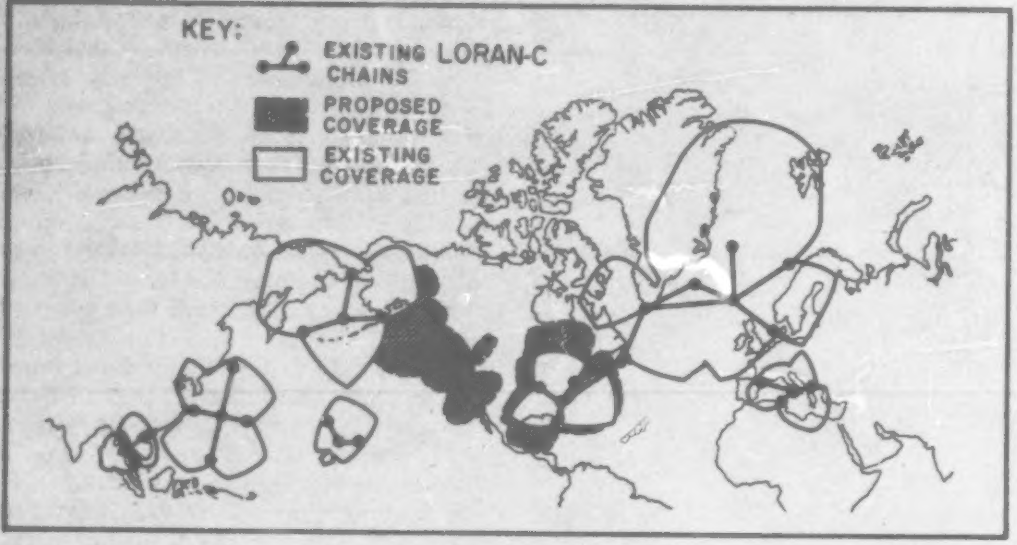
Doppler information is transmitted to the computing center, and there the information is used to calculate the satellite's position as a function of time. From the computing station the satellite's position (as a function of time) is transmitted to the injection station.

The injection station transmits orbital data to the satellite as it passes into range. The information sent from the injection station erases former data and allows the correct data to be transmitted by the satellite. The injection station sends corrective data to each satellite twice a day.

Meanwhile, the satellite continues to radio information every 2 minutes. Any ship within receiving range of the satellite can record the doppler shift, orbital position, and time as they are radioed from the satellite. By means of this information, the navigator of the ship can compute the latitude and longitude of his ship.

LORAN—C

Loran-C is a pulsed low-frequency (LF), hyperbolic radio navigation system. It derives its high accuracy from time difference measurements of the pulsed signals and the inherent stability of LF propagation. The wide



69.151

Figure 11-14.–Groundwave coverage existing and proposed worldwide.

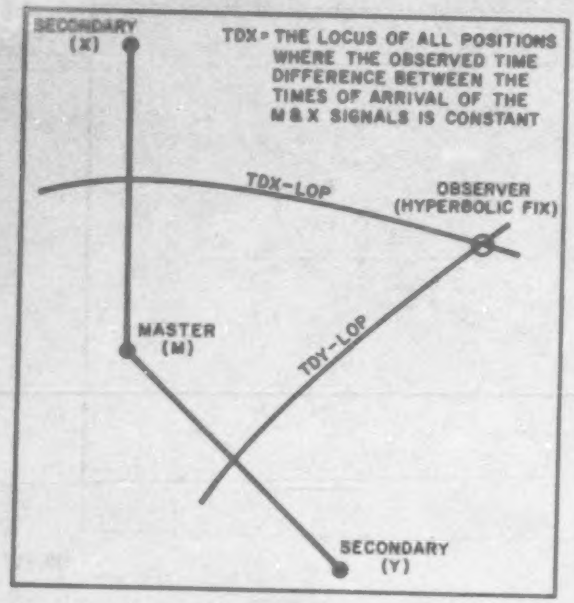
coverage areas are made possible by the low propagation losses of LF groundwaves and the resultant long baseline lengths (station-to-station separation). The Coast Guard currently is responsible for the operation of 7 Loran-C chains (including one on the east coast of the United States) using 27 transmitting stations to provide coverage over 16,000,000 square miles. Thirteen additional stations are planned to complete the coverage of the United States Coastal Confluence Zone (CCZ) and a large portion of the Northern Hemisphere (See figure 11-14.)

Hyperbolic navigation systems operate on the principle that the difference in time of arrival of signals from two stations, observed at a point in the coverage area, is a measure of the difference in distance from the point of observation to each of the stations (see figure 11-15). The locus of all points having the same observed difference in distance to a pair of stations is a hyperbola, called a line of position (LOP). The intersection of two or more LOPs defines the position of the observer. The accuracy of any hyperbolic navigation system depends on the observer's ability to measure the difference between the times of arrival of two signals (time difference, or TD), and his knowledge of the propagation conditions, so that the time differences can be converted to LOPs.

In identifying the proper frequency for a radio navigation system which will give wide coverage and high accuracy, various physical factors must be considered. The basic limitation on accuracy is the velocity of propagation of radio energy, approximately one foot per nanosecond (1 ft/nsec). Thus, for accuracies on the order of tens or hundreds of feet, measurements must be made to tens or hundreds of nanoseconds.

To take advantage of the stable propagation characteristics and long range of the LF band, 100 kilohertz (kHz) was chosen as the center frequency of the Loran-C system. The Loran-C pulse shape is such that 99% of the radiated energy is contained between the frequencies of 90 and 110 kHz.

Ranges of 800 to 1200 nautical miles (NM) are typical, depending on transmitter power, receiver sensitivity, and losses over the signal path. Variations in propagation losses, and velocity, increase with distance from the


SECONDARY
(X)
TDX = THE LOCUS OF ALL POSITIONS WHERE THE OBSERVED TIME DIFFERENCE BETWEEN THE TIMES OF ARRIVAL OF THE M & X SIGNALS IS CONSTANT
TDX-LOP
OBSERVER
(HYPERBOLIC FIX)
MASTER
(M)
TDY-LOP
SECONDARY
(Y)

69.152

Figure 11-15.—Hyperbolic fix geometry.

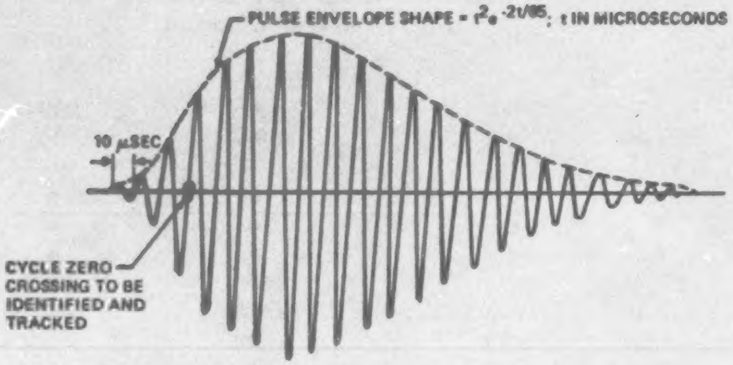
transmitters. These errors, and those introduced by receivers, will normally result in position variations of 50 to 200 feet at 200 to 500 NM, increasing to approximately 500 feet at 1000 NM.

Loran-C chains are comprised of a master transmitting station; two or more secondary transmitting stations; and, if necessary, system area monitor (SAM) stations. The transmitting stations are located such that the signals from the master and at least two secondary stations can be received throughout the desired coverage area. For convenience, the master station is designated by the letter "M" and the secondary stations are designated W, X, Y, or Z. Thus, a particular master-secondary pair and the TD which it produces can be referred to by the letter designations of both stations or just that of the secondary (e.g., MX time difference or TDX).

The transmitting stations of a Loran-C chain transmit groups of pulses at a specified group repetition interval (GRI). Each pulse has a 100-kHz carrier and is of the shape described in figure 11-16. For each chain a minimum GRI is selected of sufficient length so that it contains time for transmission of the pulse group from each station (10,000 microseconds for the master and 8000 microseconds for each secondary) plus time between each pulse group so that signals from two or more stations cannot overlap in time anywhere in the coverage area. (See figure 11-17.) Thus, with respect to the time of arrival of the master, a secondary station will delay its own transmissions for a specified time, called the secondary coding delay. The minimum GRI is therefore a direct function of the number of stations and the distance between them. A GRI for the chain is then selected so that adjacent chains do not cause mutual (cross-rate) interference. Possible values for GRI are listed in table 1. The GRI is defined to begin coincident with the start of the first pulse of the master group.

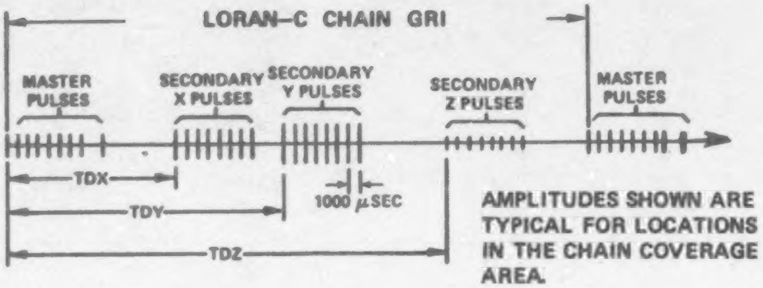
Each station transmits one pulse group per GRI. The master pulse group consists of eight pulses, spaced 1000 microseconds apart, and a ninth pulse 2000 microseconds after the eighth. Secondary pulse groups contain eight pulses spaced 1000 microseconds apart. Multiple pulses are used so that more signal energy is available at the receiver, improving significantly the signal-to-noise ratio without having to increase the peak transmitted power capability of the transmitters. The master's ninth pulse is used for visual identification of the master and for blink. Blink, used to warn users that there is an error in the transmissions of a particular station, is accomplished by turning the ninth pulse on and off in a specified code. The secondary station of the unusable pair also blinks by turning its first two pulses on and off. Most modern receivers automatically detect secondary station blink only; this is sufficient to trigger alarm indicators.

The rate structure for Loran-C is limited in theory to GRIs of 00010 to 99990 microseconds in 10 microsecond steps. In actual practice the GRIs will be between 40000 and 99990 microseconds with limits placed on rates actually selected. The designation of a Loran-C rate is by the first four digits of the specific GRI. This is a newly expanded rate structure.


PULSE ENVELOPE SHAPE = $t^2e^{-2t/65}$; t IN MICROSECONDS
10 μSEC
CYCLE ZERO CROSSING TO BE IDENTIFIED AND TRACKED

69.153

Figure 11-16.—Loran-C pulse.


LORAN–C CHAIN GRI
MASTER PULSES
SECONDARY X PULSES
SECONDARY Y PULSES
SECONDARY Z PULSES
MASTER PULSES
TDX
TDY
TDZ
1000 μSEC
AMPLITUDES SHOWN ARE TYPICAL FOR LOCATIONS IN THE CHAIN COVERAGE AREA.

69.154

Figure 11-17.—Example of received Loran-C signal.

The old rate structure consisted of those GRIs with old rate designations shown in parentheses (thus rate SS7 is now referred to as 9930). The existing eight Loran-C chains will continue to use rates from the old rate structure.

OMEGA

Omega is a very low-frequency (VLF) radio navigation system which will enable navigators to obtain reliable positions comparable in accuracy to Loran-A on a worldwide and nearly continuous basis, when the system is in full operation, with only eight transmitting stations. Loran-A, with 81 transmitting stations in 1974, provides only 65% coverage of the Northern Hemisphere.

Seven of the Omega stations are either now located in or will be located in North Dakota, Liberia, Norway, Argentina, Ile de la Reunion in the Indian Ocean, Hawaii, and Japan. The eighth

Table 11-1.—Group Repetition Intervals
(GRI in Tens of Microseconds)

9999	8999	7999	6999	5999	4999
9998	8998	7998	6998	5998	4998
9997	8997	7997	6997	5997	4997
●	●	●	●	●	●
●	●	●	●	●	●
●	●	●	●	●	●
9991	8991	7991	6991	5991	4991
9990 (SS1)	8990	7990 (SL1)	6990	5990 (SH1)	4990 (S1)
9989	8989	7989	6989	5989	4989
●	●	●	●	●	●
●	●	●	●	●	●
●	●	●	●	●	●
9971	8971	7971	6971	5971	4971
9970 (SS3)	8970	7970 (SL3)	6970	5970 (SH3)	4970 (S3)
9969	8969	7969	6969	5969	4969
●	●	●	●	●	●
●	●	●	●	●	●
●	●	●	●	●	●
9931	8931	7931	6931	5931	4931
9930 (SS7)	8930	7930 (SL7)	6930	5930 (SH7)	4930 (S7)
9929	8929	7929	6929	5929	4929
●	●	●	●	●	●
●	●	●	●	●	●
●	●	●	●	●	●
9000	8000	7000	6000	5000	4000

station may be located in Australia. The average station separation is to be 5000 to 6000 nautical miles. With the transmitting stations so situated, the extremely long ranges of the VLF signals (10-14 kHz) will ensure that the user will be able to receive at least three stations. Depending upon his location, the user may be able to receive as many as six stations. From five stations, for example, users will be able to derive ten lines-of-position (LOPs) from phase comparisons of signals transmitted from various combinations of pairs of the transmitting stations. This LOP redundancy will permit navigators to be selective with respect to LOPs used to fix their positions. If some signals are transmitted along paths with poor propagation conditions, other signals transmitted under favorable conditions should be available. Also, navigators will be able to select those LOPs which provide more accurate positions because of the crossing angles or angles of cut of the lines.

The practicality of the Omega system is based on the fact that the radio signals in the VLF band have very good phase stability over extremely longdistances. The accuracy of the system is dependent upon this inherent stability and the predictability of the phase variations along the propagation path. Long-term studies indicate that the Omega signal phase, which varies diurnally along the path in response to diurnal changes in the ionosphere, can be predicted with enough accuracy to enable positioning to within 1 to 2 nautical miles RMS (root mean square).

OMEGA LANES

With the stations transmitting at 10.2 kHz, the wavelength is approximately 16 nautical miles. Thus, identical phase angles are repeated at 16-mile intervals. However, on the baseline between two transmitting stations a specific difference in the phase angles of the radio waves received from the two transmitting stations repeats itself every one-half wavelength or about every 8 miles.

Since a representative baseline in the Omega system is about 5000 nautical miles in length, or about 300 wavelengths at 10.2 kHz, specific phase-angle differences in the 10.2-kHz signal field are repeated about 600 times on the baseline. Hence, at 10.2 kHz there are about 600 points on the baseline at which the phase-angle differences are zero.

Contours connecting points in the signal field at which the phase-angle differences are zero are the constant phase or isophase contours plotted on Omega charts and tabulated in the Omega lattice tables. At 10.2 kHz each such contour is spaced at intervals of about 8 nautical miles on the baseline. Away from the baseline there is a small divergence of the hyperbolic contours.

The area lying between two zero phase-difference contours is known as an Omega lane. Thus, on the baseline between two stations transmitting at 10.2 kHz, the lane width is about 8 nautical miles. Each such pair of stations transmitting at 10.2 kHz produces a pattern of about 600 lanes. Away from the baseline the lane width for 10.2-kHz transmissions increases gradually. When the two transmitting stations and the receiver form an equilateral triangle (the receiver being 4300 nautical miles from the baseline), the lane width will have increased to about 12 nautical miles.

In the ranging mode of operation, the lane is the area lying between two zero phase-difference contours within which there is a 360° change in phase of the CW wave received from a single transmitting station as the receiver is moved from one isophase contour to the other. Thus, in the ranging mode, lane width at 10.2 kHz is constant at about 16 nautical miles.

Normally, the lane counter of the AN/SRN-12 Omega receiver (figure 11-18), which is set on departure from a known position, provides the lane. If the lane counting capability of the equipment is lost for any reason, such as temporary equipment failure, the navigator usually can determine the lane he is in by dead reckoning or other navigational means.

STATION LOCATIONS AND COVERAGE

The Omega stations transmitting in 1975, their letter designators, and approximate locations are given in figure 11-19. The fix accuracy is determined from the system geometry, using a standard deviation of 4 centilanes for each of the two LOPs making up the fix. The error as stated for the standard deviation of the fix is measured from the arithmetic mean of the positions which could be established from a large number of observations at a given place and time. Therefore, this distance does not indicate the separation between the fix position and the observer's actual position, except by chance. With the error stated in terms of the standard deviation (lo), 68% of the cases should result in a position displacement in any direction from the arithmetic mean not exceeding the distance specified for lo.

CHARACTERISTICS OF THE OMEGA TRANSMISSION

Omega is a VLF, continuous wave, time shared radio navigation system with all stations transmitting at the same frequencies. The stations always transmit in the same order, with the length of each transmission varying between 0.9, 1.0, 1.1, and 1.2 seconds from station to station. The order and lengths of the station transmissions at 10.2 kHz, in accordance with the Omega station identification code, are contained in table 11-2.

THE SIGNAL FORMAT

As shown in figure 11-20, the order of transmission is such that when station A

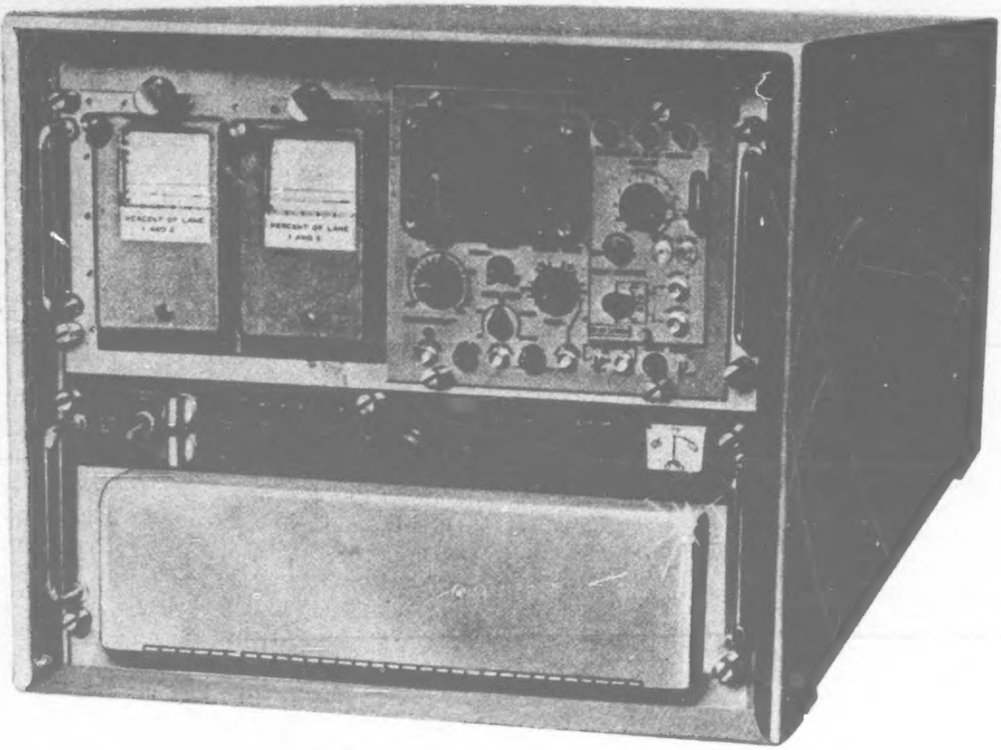


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Figure 11-18.—AN/SRN-12 Omega shipboard navigation receiver.

transmits at 10.2 kHz, stations G and H transmit at 11.33 kHz and 13.6 kHz, respectively, for the same time duration that station A transmits at 10.2 kHz. When station B transmits at 10.2 kHz, stations A and H transmit at 13.6 kHz and 11.33 kHz, respectively, for the same time duration that station B transmits at 10.2 kHz, and so on until the whole sequence of transmissions has been completed. Since there is a time interval of 0.2 seconds between transmissions, the entire cycle of the commutation pattern is repeated every 10 seconds. The start of one of the

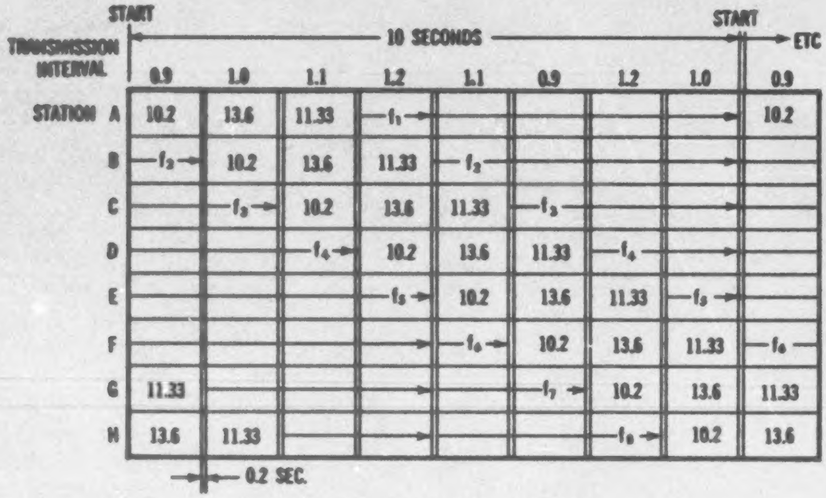
Omega Stations

Letter Designations	Station Name	Approximate Location	
		Latitude	Longitude
A	Omega Norway	66° N	13° E
B	Omega Trinidad	11° N	62° W
C	Omega Hawaii	21° N	158° W
D	Omega North Dakota	46° N	95° W
H	Omega Japan	35° N	129° E

Figure 11-19.—Omega coverage diagram.

Table 11-2.—Omega Commutation Pattern

Station	A	B	C	D	E	F	G	H
Length of Transmission in seconds	0.9	1.0	1.1	1.2	1.1	0.9	1.2	1.0



STATION	0.9	1.0	1.1	1.2	1.1	0.9	1.2	1.0	0.9
A	10.2	13.6	11.33	f_1					10.2
B	f_2	10.2	13.6	11.33	f_2				
C		f_3	10.2	13.6	11.33	f_3			
D			f_4	10.2	13.6	11.33	f_4		
E				f_5	10.2	13.6	11.33	f_5	
F					f_6	10.2	13.6	11.33	f_6
G	11.33					f_7	10.2	13.6	11.33
H	13.6	11.33					f_8	10.2	13.6

69.155

Figure 11-20.—Order of transmission.

segments of the 10-second cycle is synchronized with coordinated universal time (UTC).

The 0.2-second interval between transmissions rules out the possibility of overlapping of the signals received from different stations. The 0.2-second interval between transmissions also eases the requirement for perfect alignment of the receiver commutator. A 0.1-second error in setting the commutator cycle has negligible effect.

IDENTIFICATION OF THE OMEGA SIGNAL

Depending upon the observer's distance from the various transmitters, the Omega signals are of differing amplitude or strength. The relative strengths of the signals received and the time sequence of transmission can be used to identify the Omega signal.

By the signal strength method of identification, the various stations can be recognized either by the relative sound levels or by the heights of the signals on an oscilloscope. In identifying the stations aurally, the signals from the nearer stations will sound relatively loud, whereas the signals from the more distant stations will be relatively weak, or they may not be heard. On an oscilloscope display, the amplitudes of the signals from the nearer stations will be relatively large, whereas the amplitudes of the signals from the more distant stations will be relatively small, or the signals may not be seen. It should be kept in mind, however, that these methods depend upon observing or listening to the entire signal format. The transmission from any single transmitter can be distorted by propagation effects; and, unless all the signals are taken into consideration, an erroneous lane count can be established. Also, "long path" signals, or signals which travel the longer of the two possible great-circle paths from the transmitter, degrade this technique.

Each of the eight transmissions during the 10-second period of transmitting the complete sequence of signals is called a time segment. The first transmission in the sequence is segment A, the second is segment B, etc. (the time segment designation should not be confused with the station designations). A particular station can be identified by observing the relative time of its transmissions in the segment sequence. The 13.6-kHz transmission from station B (now Trinidad but scheduled to be Liberia) occurs during time segment C; the 13.6-kHz transmission from station C (Hawaii) occurs during time segment D (the commutation cycle in the receiver must be synchronized so that this condition occurs). By reference to standard time transmissions (WWV, WWVH, etc.), the start of the sequence of transmissions can be determined. Through identification of the various time segments, the various stations can be identified.

When Omega is compared with the other radio navigation systems discussed in this chapter, the fact that worldwide coverage is achieved with an accuracy of ± 1 to 2 miles RMS with only eight stations is a tremendous advantage. For coastal navigation, however, the greater accuracy afforded by the other systems, particularly Loran-C, close to their baselines makes their use valuable, especially when a vessel is slightly beyond radar range to land. For this reason, it is not meaningful to attempt to compare the various systems by the use of system accuracy along, inasmuch as the RMS accuracy of all systems with the exception of Omega varies from a few hundred yards to several miles within the area of system coverage.

OTHER SYSTEMS

Several other electronic navigation systems that are available but less widely used in the Navy are Decca, Consol, Shoran, Star Tracker, SINS, and NAVDAC.

DECCA

Decca is a British system, which, like loran, requires special receiving equipment. The receiving unit measures phase differences between a master and a group of three slave stations, all of which are transmitting at different frequencies. Fixes are obtained by plotting the phase differences directly onto a chart printed with Decca hyperbolic lines.

CONSOL

Consol is a long-range, short-baseline system that operates in the 250- to 350-kHz frequency range. Consol signals may be received by using ordinary radio equipment. The signals consist of a series of dots and dashes, which are counted by the receiving operator. Dotted and dashed lines printed on Consol charts are used to plot fixes.

Complete information on Decca and Consol may be found in American Practical Navigator, Pub No 9.

SHORAN

Shoran (from the underlined letters of the term short-range navigation), employed principally in surveying, uses ranges rather than bearings. Signals from own ship's radar automatically trigger two fixed transmitters ashore. The signals emitted by these transmitters are in the form of pips and are received simultaneously. You measure the ranges to these pips in the same manner as you would any contact, and then plot the ranges on your chart. The point where these two ranges intersect is your position. Although Shoran is relatively short-ranged, it is extremely accurate, so that your fix can be relied on to about 50 feet.

STAR TRACKER

Star Tracker is an extremely sensitive optical telescope with radio or infrared components that calculate elevation (altitude) and azimuth data from celestial bodies, including the Sun. The Star Tracker may be used even during periods of poor visibility. With the Sun it may be used effectively in heavy overcasts with a high degree of accuracy. The radio sextant is similar to the radio telescope and is included in the same category as the Star Tracker.

SHIP'S INERTIAL NAVIGATION SYSTEM

At present, the ship's inertial navigation system (SINS) is chiefly a navigational aid for submarines and aircraft carriers. It soon should be operational on most surface vessels.

The SINS provides ships with an accurate and continuous dead-reckoning position. The DR position is displayed continuously on a chart, along with the desired track. Because SINS is a self-contained system, it is a valuable war-time navigational aid. When the loran systems and other similar systems are knocked out, SINS remains operable.

The SINS operates on an arrangement of gyros and accelerometers. This arrangement is called the sensitive element. Three gyros and two accelerometers make up this sensitive element. Two of the gyros give absolute values, one gyro for latitude and the other for the vertical. The third gyro is for longitude, but it cannot give an absolute value. A requirement for the third gyro is the initial ship's longitude, with which ship's position can be computed at any time thereafter.

The accuracy usually obtained by SINS is on the order of about 1 mile per day. The degree of accuracy can be increased, however, because more accurate position data can be obtained by other navigational methods and inserted into the SINS.

NAVDAC

Among the advanced components to navigational systems that assist the navigator in solving navigational problems is Navdac (navigation data assimilation computer). The Navdac combines, evaluates, and stores data received from navigational systems, i.e., SINS, Loran-C, and Star Tracker. In effect, it is a memory bank of highly accurate navigational data, capable of rejecting solutions of poor quality and accepting only those of a high degree of probable accuracy.

In closing this chapter, it must be pointed out that no single method of navigation should be used to the exclusion of all others. Even the newer electronic navigational systems cannot be considered cure-alls. These systems are made up of highly complex pieces of equipment and are subject to various types of casualties. Unusual atmospheric conditions will affect some of them, and severe sea conditions will influence others. Complete reliance upon one system alone, to the extent of excluding all other methods or systems of navigation, cannot and must not be practiced. There is no perfect system or method of navigation under all conditions.

CHAPTER 12

CELESTIAL NAVIGATION

Piloting (including its electronic phases) and dead reckoning compose that branch of navigation that determines position by reference to objects or localities on the Earth. Another branch, in which position is determined by the aid of heavenly bodies, such as the Sun, Moon, stars, and planets, is called celestial navigation. An accurately timed and measured, and properly corrected altitude on any navigational body gives an accurate line of position. Navigation by such lines of position is the crux of modern seafaring.

NAUTICAL ASTRONOMY

Astronomy is the scientific study of the celestial bodies, including their magnitudes, motions, constitutions, positions, and distances. Nautical astronomy is that part of astronomy on which celestial navigation is based. You must know something about nautical astronomy before you can acquire a knowledge of celestial navigation.

CELESTIAL SPHERE

Although we know that the Earth is not a perfect sphere, we consider it to be so for many navigational purposes. All problems in celestial navigation involve the use of two spheres. One such body is the Earth itself, and the other is an imaginary celestial sphere.

Let's go back again and use the lighted transparent sphere with which we illustrated a chart projection. Assume the sphere is the size of a tennis ball, with the Earth's meridians and parallels laid out on it in black. Assume further that it is suspended in the exact center of another sphere, made of glass, about the size of a basketball.

The basketball-sized sphere, on which the meridians and parallels are projected from the smaller one, represents the imaginary celestial sphere on which all the heavenly bodies are presumed to be located. The entire system of navigation by the stars is founded upon the fact that angular distances on the celestial sphere can be reduced to fit the Earth (terrestrial sphere). This system makes it possible for a navigator to locate objects on the Earth with reference to the locations of heavenly bodies on the celestial sphere.

As you know, objects are located on the terrestrial sphere by a system of coordinates called latitude and longitude. Latitude lines (parallels) are parallel to the Equator and are used to indicate distance north or south of the Equator. On the Mercator chart, longitude lines (meridians) cross the Equator at right angles and are used to indicate distance east or west of the Greenwich meridian. Objects on the celestial sphere are located in a similar manner, but the horizontal lines are called declination, and the vertical lines are called Greenwich hour angle (GHA).

Longitude is measured on the terrestrial sphere east and west from the Greenwich meridian (G) along the Equator, as you already know. The GHA of a body on the celestial sphere is measured westward from the projected Greenwich meridian to the body's hour circle.

What is an hour circle? It is half of a great circle on the surface of the celestial sphere which passes through a celestial body and terminates at the celestial poles. The hour circle, contrasted to the celestial meridian, moves with the celestial body progressively with time from east to west (since we consider apparent motion), while the position of the celestial meridian remains fixed. With knowledge of the Earth's rotation (one turn upon its axis per 24 hours), we realize that each celestial body crosses our meridian once each 24 hours. Dividing 360° (number of degrees in a circle) by 24 hours, we find that an hour circle advances about 15° per hour.

The GHA of any body is the degrees, minutes, and tenths of minutes of arc of the celestial equator intercepted at a given instant between that body's hour circle and the celestial meridian of Greenwich, measured westward from Greenwich through 360°. Whether measured on the celestial or the terrestrial sphere, the amount of arc is the same. Figure 12-1 shows you GHA of a star measured on the terrestrial sphere.

Notice that the star's position on the terrestrial sphere is indicated by GP. The letters GP stand for geographic position, and represent the point where a line drawn from the center of the Earth to the body would intersect the Earth's surface. Depending on whether the body in question is the Sun, the Moon, or a star, a GP may be variously a subsolar, sublunar, or substellar point.

You can see from figure 12-1 how closely GHA corresponds to longitude. Remember, however, that GHA of any body increases continuously as the body moves westward; whereas, longitude remains the same for any point on the Earth. The GHA is always measured westward from Greenwich (0°) through 360°. Longitude is measured east or west from Greenwich to 180°.

The GHA of any navigational body of the solar system (Sun, Moon, and planets) and of the first point of Aries (♈), sometimes called vernal equinox, is listed in the Nautical Almanac for every hour of GMT, for any date. The first point of Aries (♈) is the zero point on the celestial equator from which the westward distance of the stars is measured. The GHA of any navigational star may be determined from the Nautical Almanac by adding GHA of Aries to the tabulated sidereal hour angle (SHA) of the star. Let's see what all these explanations mean.

SIDEREAL HOUR ANGLE

Refer to figure 12-1 again. The marking "hour circle of vernal equinox" is the line from which sidereal hour angle is measured. The SHA of any star is measured westward through 360°, like GHA; but measurement is from the vernal equinox or first point of Aries, instead of from Greenwich.

At the present time you must bear in mind two points. GHA of the vernal equinox, like GHA of any other body, is increasing continuously westward. But the sidereal hour angle of any star (measured westward from the vernal equinox to the body's hour circle) remains relatively constant. Why? Simply because all the stars move westward along with the vernal equinox. The SHA of any body changes slightly, and its tabulated value in the Nautical Almanac varies slightly throughout the year. The reasons for the changes are beyond the scope of this course.

You will see later that the SHA and GHA of the vernal equinox are factors used in star observations. However, neither is applicable in observations of navigational planets.

DECLINATION

You know that the GP you see on the small sphere in figure 12-1 corresponds to the star's location on the celestial sphere. You know that latitude of a point on the terrestrial sphere is measured from the Equator northward or southward along the point's meridian, to a maximum of 90°. Declination of a body on the celestial sphere is measured in exactly the same way–from the celestial equator (equinoctial) northward or southward along the body's hour circle. The polar distance is the number of degrees, minutes, and tenths of minutes of arc between the heavenly body and the elevated pole. The elevated pole is the one above the horizon; in other words, the one with the same name as your latitude.

From the foregoing description, it follows that the polar distance of a body whose declination has the same name (north or south) as the elevated pole is always 90° minus its declination (d). Polar distance of a body whose declination has a different name from that of

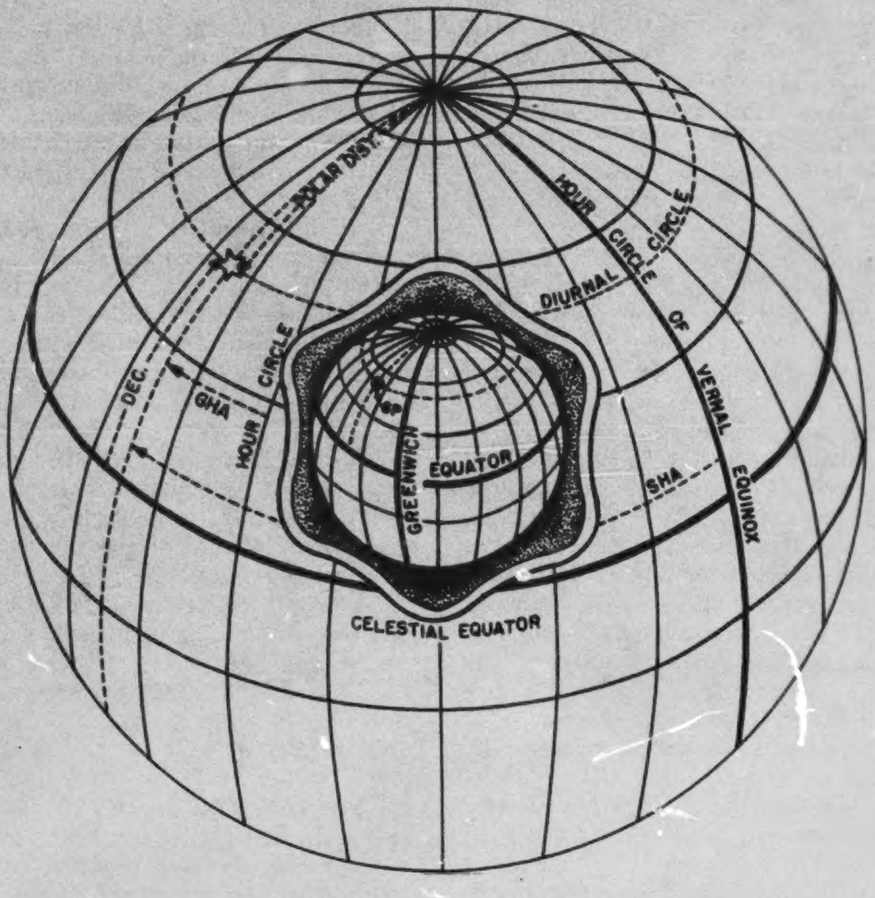


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Figure 12-1.—The celestial sphere.

the elevated pole is always 90° plus d. Remember this rule because it is the basis of the system for determining latitude by observations taken at local apparent noon (LAN), which is covered later in this chapter.

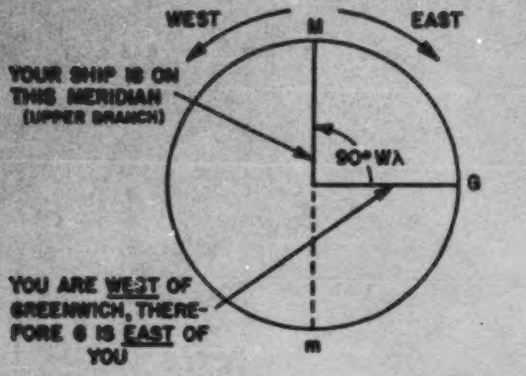
Declination of any navigational star is listed in the Nautical Almanac for each date. Declination of each body of the solar system is listed for every hour GMT.

TIME DIAGRAM

So far you have learned that a heavenly body is located on the celestial sphere by its Greenwich hour angle (corresponding to longitude) and its declination (corresponding to latitude). You have seen how both of these coordinates are measured and how, from them, the GP of a heavenly body can be located on the terrestrial sphere.

Before going further into nautical astronomy, you should acquire a knowledge of the use of the diagram on the plane of the celestial equator (time diagram), which not only will make it easier for you to understand the ensuing discussion but will simplify the solution of your celestial navigation problems.

In the time diagram, the observer is theoretically located outside the celestial sphere, over its south pole. The diagram consists merely


WEST
M
EAST
YOUR SHIP IS ON THIS MERIDIAN (UPPER BRANCH)
90°Wλ
G
YOU ARE WEST OF GREENWICH, THEREFORE G IS EAST OF YOU
m

69.57

Figure 12-2.—Locating G on the time diagram, ship in 90°Wλ.

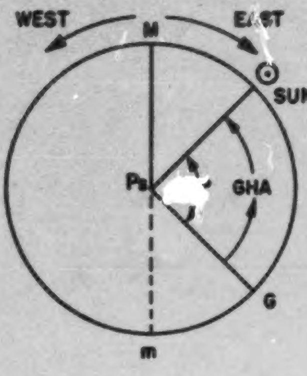


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Figure 12-3.—GHA of the Sun on a time diagram.

of a circle representing the celestial equator. The center of the circle is the south celestial pole. Counterclockwise direction is westerly. The local meridian is drawn in as a vertical line, thus placing the upper branch (M), which is the arc of a celestial meridian between the poles, at the top of the diagram and the lower branch (m) at the bottom. To avoid confusion, the lower meridian is shown by a dashed line.

You locate the Greenwich meridian by means of your longitude (symbol λ). If you were in 90°W longitude, G would appear on your diagram 90° clockwise from M because you're counterclockwise or west of G. A glance at figure 12-2 will confirm this location. What you really do, then, is count from M toward Greenwich, the direction depending upon whether you are in east or west longitude.

Figure 12-3 shows another time diagram on which GHA of the Sun is indicated. The upper branch of the Sun's hour circle is shown as a solid line. The angle, or arc of the celestial equator, between the Greenwich meridian and the Sun's hour circle is 90°. Therefore, GHA of the Sun at this instant is 90°. Remember, GHA is always measured westward from G.

The GHA of a star is measured in the same direction from Greenwich to the star. Because the SHA enters the picture here, however, your method of locating a star on the time diagram is somewhat different. First, you must locate the vernal equinox by its tabulated GHA. Let's say GHA of the vernal equinox for the time of your observation is 45°. You locate the vernal equinox 45°W from Greenwich, as shown in figure 12-4. The symbol that resembles a pair of ram's horns represents the vernal equinox.

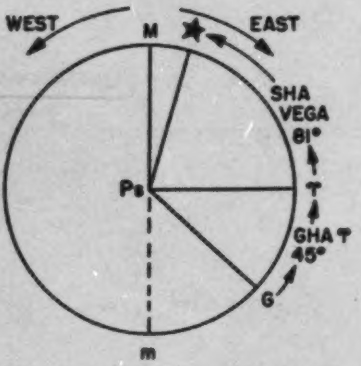

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Figure 12-4.—Locating vernal equinox and star on time diagram.

From the Nautical Almanac you find SHA of the star in question. You already know that SHA is measured to the west from the vernal equinox. All you have to do here is find the SHA of this star, measure SHA westward from the vernal equinox, and you have the star located on the time diagram. Let's say it's the star Vega, whose SHA is approximately 81°.

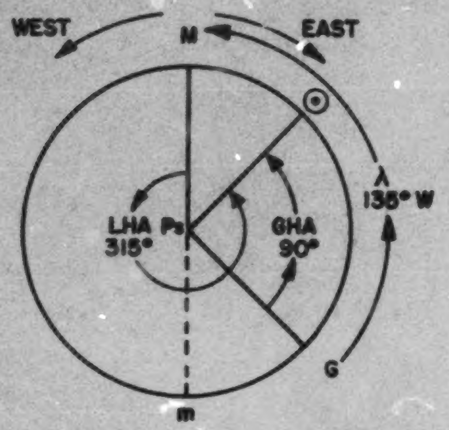

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Figure 12-5.—LHA on the time diagram.

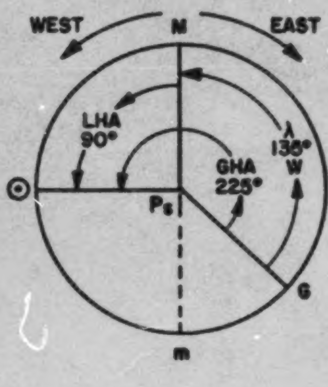

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Figure 12-6.—LHA, with Sun west of your celestial meridian.

Figure 12-4 shows you Vega located on the time diagram.

It's easy to see here that GHA of Vega must be equal to GHA of the vernal equinox plus SHA of Vega. GHA (Vega) = GHA (♈) + SHA (Vega). In this example GHA of Vega is 81° plus 45°, or 126°.

Now let's use the time diagram to explain some more facts about nautical astronomy.

LOCAL HOUR ANGLE (LHA)

Local hour angle is the name given to the angle of arc (expressed in degrees, minutes, and tenths of minutes) of the celestial equator between the celestial meridian of a place and the hour circle of a heavenly body. It is always measured westward from the local meridian through 360°.

Let's work this problem of LHA on a time diagram. Say you're in 135°W longitude. You know your own meridian is represented by M. Measure approximately 135° from M toward Greenwich, which means, of course, that Greenwich will be shown east of M. Think it over for a moment—you're to the west of Greenwich, therefore Greenwich is to the east of you.

Now that we know where Greenwich is and where you are, let's take the Sun as we had it in figure 12-3 and try to figure out its LHA. Figure 12-5 shows us that the Sun is 90° west of Greenwich. We know that LHA is always measured westward from your local meridian (M) to the hour circle of the body (in this example, the Sun). Therefore, LHA here is the whole 360° around, minus the 45° between the Sun's hour circle and M. This 45° may be found by inspecting figure 12-5 or by subtracting 90° from 135°. Let's think this over—we're 135°W of Greenwich, therefore G is 135° clockwise of us. The Sun is 90°W or counterclockwise of G. The difference is the 45° we mentioned. Subtract this 45° from 360° and we get 315°, the LHA.

Look again at figure 12-5. As you can see, the Sun was east (clockwise on the diagram) of your local meridian (M). Now let's suppose that you're in the same longitude (135°W) but GHA of the Sun is 225° instead of 90°. The time diagram will appear as in figure 12-6. The Sun is now west of your meridian (M). The LHA is always measured westward from the local celestial meridian to the hour circle of the body. Therefore, LHA is the 90° from M to the Sun's hour circle.

Here are two general rules that will help you in finding LHA when GHA and longitude are known:

$$LHA = GHA - \lambda W$$
$$LHA = GHA + \lambda E$$

In west longitude it may be necessary to add 360° to GHA before the subtraction can be

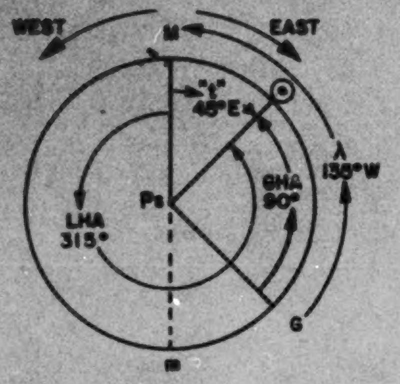

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Figure 12-7.—Meridian angle (t), with Sun E of M.

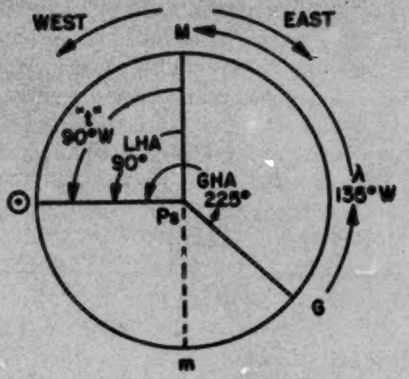

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Figure 12-8.—Meridian angle (t), with Sun W of M.

made. In east longitude 360° is dropped from LHA if it exceeds this amount. Be sure, however, to check the accuracy of your work by referring to a time diagram. It offers a graphic means of obtaining the data you need.

MERIDIAN ANGLE (t)

Meridian angle (symbol t) is another value used in solving problems of celestial navigation. It is defined as the arc of the celestial equator between the local meridian of a place and the hour circle of a heavenly body, measured east or west through 180°. Notice the difference between LHA and t. The LHA is measured west through 360°. The t is measured east or west through 180° and must be labeled E or W.

Let's try a sample on a time diagram (figure 12-7). We'll keep the same longitude (135°W) and assume the Sun's GHA is 90°. You can see by a glance at the diagram that the Sun is east of M. Inasmuch as t is measured east or west from M through 180°, it follows that here t is equal to GHA subtracted from longitude, or 45°E.

Again, with the same longitude, assume the Sun's GHA is 225° (figure 12-8). The time diagram shows you that the Sun is west of M. Then t is measured to the west and amounts to the longitude subtracted from GHA, or 90°W.

Another look at the diagram will show you that when the body is west of M, t is the same as LHA. (An obvious point here is that meridian angle of the Sun is always east before local apparent noon and west afterwards.) It is an absolute necessity for you to know whether t is east or west. The time diagram is the best means of finding out this information.

ELEMENTARY NAVIGATION

The rest of this chapter approaches actual navigation only in the most general way. To begin with, we know that a fix by celestial observation is the point at which two or more lines of position (LOP) intersect. To understand what a celestial LOP is, we first must grasp the concept of circles of equal altitude.

Imagine a straight line drawn from a celestial body perpendicular to the surface of the Earth. Where this line intersects the Earth is the GP of the star. If you stood at this point (the GP of the star) and took a sight, you'd get an altitude of 90°. The star, in other words, is in your zenith (directly overhead).

Suppose you have a buddy who is standing exactly 1 nautical mile (1 ′ of arc) from you. You can see that he also is 1 nautical mile (1 ′of arc) from the star's GP. Furthermore, his zenith is 1 ′ of arc from the star's position on the celestial sphere. (The difference between the zenith of the GP of a body and the zenith of an observer is called the zenith distance.) If he takes a sight of this star just as you do, the altitude he gets will differ by 1′ from yours. Because altitude always equals 90° minus zenith distance, the sight he takes will read 89°59′.

Let's stop right here and look at a significant fact. As long as your buddy stays exactly 1 mile away, he can be in any direction from you. In other words, your position is the center of a circle. Your buddy could be anywhere on that circle and get the same 89°59′ sextant altitude. He is on a circle of equal altitude. This circle of equal altitude is a celestial LOP.

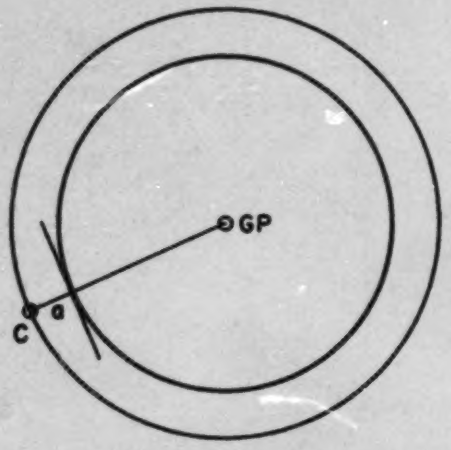
From the star's GP, any number of circles of equal altitude spread out as altitude decreases with distance of the observer from the GP. The maximum limit, of course, would be about 5400 nautical miles (5400′ of arc) from the GP, at which point the star would be seen on the horizon at zero altitude. Altitude at this limit would have decreased the entire 90° (5400′).

Now let's go back to fixes. It would seem that we could use the intersection of a circle of equal altitude of one body with a circle of equal altitude of another to obtain a fix by celestial navigation. After all, we can locate the latitude and longitude of the GP by the declination and GHA of the star. By subtracting the altitude from 90° and changing the result to nautical miles, we should be able to draw a circle of equal altitude around the GP. Unless the observed body is at a very high altitude, however, the circle of equal altitude is so far from the GP that both of them cannot appear on the same chart. What we actually do is locate a segment of the circle of equal altitude we are on. This segment, plotted as a straight line, is the LOP you see the navigator use.

The remainder of this section discusses means of determining this LOP. Although we'll cover only the elements of sight work, you should have a general understanding of what goes on, which is the aim of the following topic.

COMPUTED ALTITUDE AND AZIMUTH

In Pub No. 229 the altitude and azimuth angles of navigational heavenly bodies have been computed in advance for whole degrees of latitude and local hour angle as well as declination. Computed altitudes and azimuths for selected stars are given in Volume I of Pub No. 249. These two publications offer sight reduction tables (described later) that are the most popular ones used by present-day navigators.



69.64

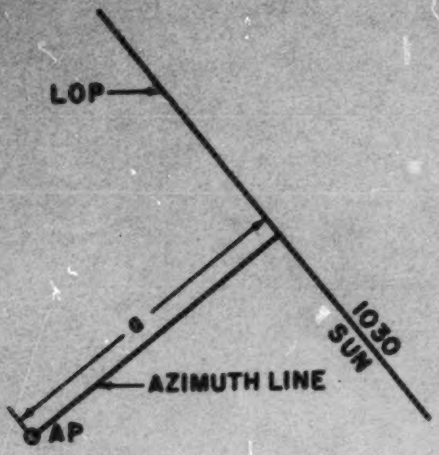
Figure 12-9.—Celestial line of position.

The azimuth line from any point to the GP of a heavenly body is actually the radius of the circle of equal altitude passing through that point. This fact is obvious in figure 12-9 where C is a point and the line CGP represents the azimuth line from C to the GP.

Assume that you're aboard ship preparing to plot an LOP from a celestial observation. You've just taken an accurately timed altitude of a particular body. You don't know exactly where you are, but you have a general idea from your DR. You take an assumed position (AP) at or near your DR. Here's where the tables of computed altitude and azimuth come in.

From the tables you can determine the computed altitude (Hc) and computed azimuth (Zn) of the body from the AP at the instant of observation only. (You can't use an observed azimuth because you're not located at the AP.)

If you drew a line through the AP along the azimuth line, your celestial LOP (that is, the circle of equal altitude you are on) would intersect this azimuth line toward or away from the body's GP. The distance toward or away is a number of nautical miles equal to the number of minutes of arc by which the Hc differs from the



69.65

Figure 12-10.—Plotting celestial line of position.

altitude you got from observation (Ho). This difference is known as the altitude intercept(a).

Let's try out these findings by referring to figure 12-9. Point C in this illustration represents the AP. Line CGP is the computed azimuth from AP to GP of the star. The circle through C is the circle of equal altitude of the AP. The inner circle is the circle of equal altitude you are on. The segment of the azimuth line between C and the inner circle is the altitude intercept (a). This intercept is as many nautical miles long as the observed altitude differs in minutes from the computed altitude.

Notice that the line of position in figure 12-10 has been plotted as a straight line perpendicular to the azimuth line. You know that a segment of a circle of equal altitude is really curved. We can plot a straight line because circles of equal altitude usually are so large that their curvature is imperceptible in the small segment used for plotting purposes.

How do we know whether the altitude intercept is to be applied for the AP toward or away from the GP? This memory aid will help you figure it: "Coast Guard Academy—Computed Greater; Away." The letters CGA, because of their order, provide a helpful code to stimulate your memory. This code means that if the computed altitude (Hc) is greater than the observed altitude (Ho), the altitude intercept (difference between them) is laid off from the AP away from the GP. If the computed altitude is less than the observed altitude, the altitude intercept (a) is laid off from the AP toward the GP.

Altitude Corrections

A few general pointers regarding altitude corrections should be mentioned here. Besides index correction (IC), which is explained later in this chapter, there are four other altitude corrections. These corrections are for refraction, dip, parallax, and semidiameter.

Refraction is the deflection of light rays from a straight line, caused by the oblique passage of the rays through different mediums of density. For simplicity, in navigation, refraction may be thought of as the bending of light rays as they pass at an angle through the layers of atmosphere. The refraction correction is always subtracted from sextant altitude.

Dip is the difference between the visible horizon at the surfacr and the visible horizon at the observer's height of eye, or height above the surface. The dip correction is always subtracted from the sextant altitude. Dip is also called height of eye.

Parallax is the difference in direction of a heavenly body as seen from some point on the Earth's surface and as seen from some other point, as from the center of the Earth.

Semidiameter is the angular distance between the limb of the body and the center. When an observer pulls down the Sun's or Moon's lower limb to the horizon, he must add a semi-diameter correction from the sextant altitude. If the upper limb is observed, the semidiameter correction must be subtracted.

Correction for observed altitude (refraction) and correction for height of eye (dip) are printed on the inside front cover of the Nautical Almanac.

Semidiameter corrections to be applied to the Sun and Moon appear in the daily pages throughout the Almanac. Index error, of course, is determined in advance for the individual sextant. During morning stars, this may be done after star sights when the horizon is clear.

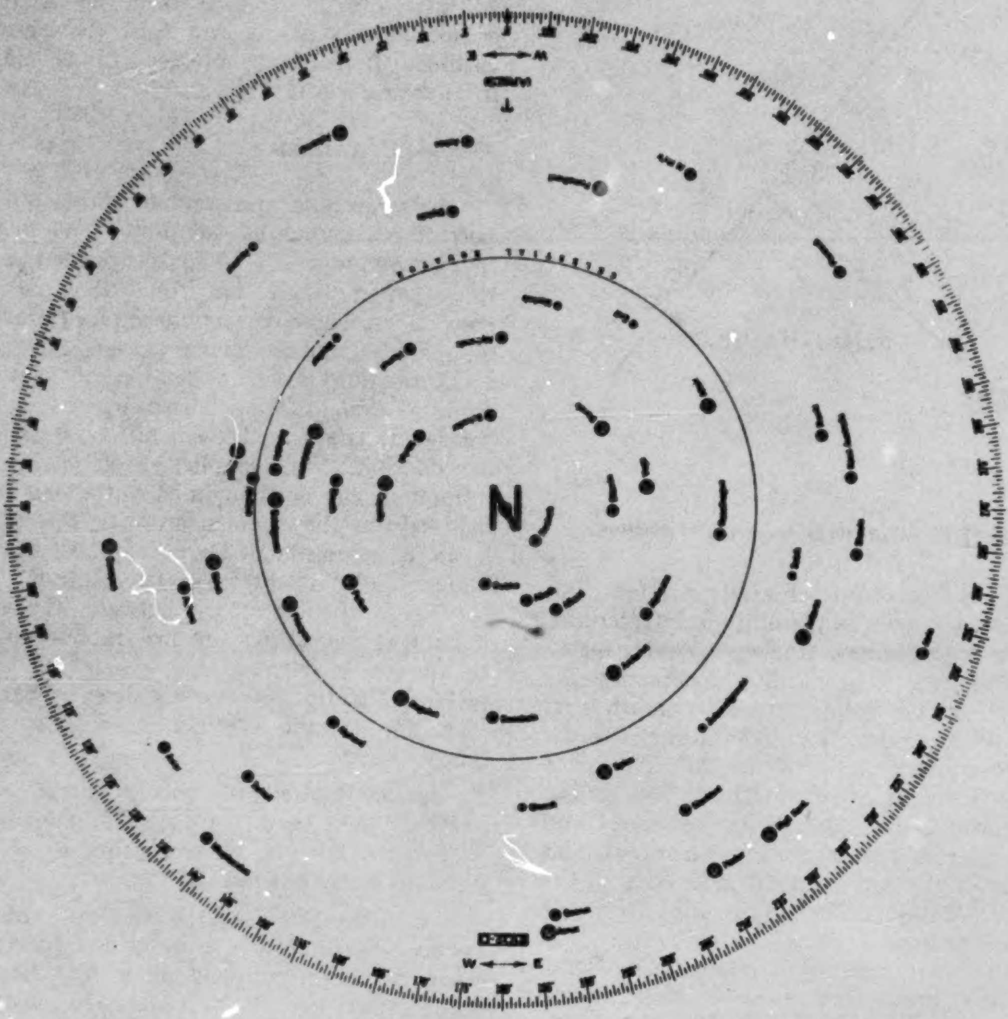


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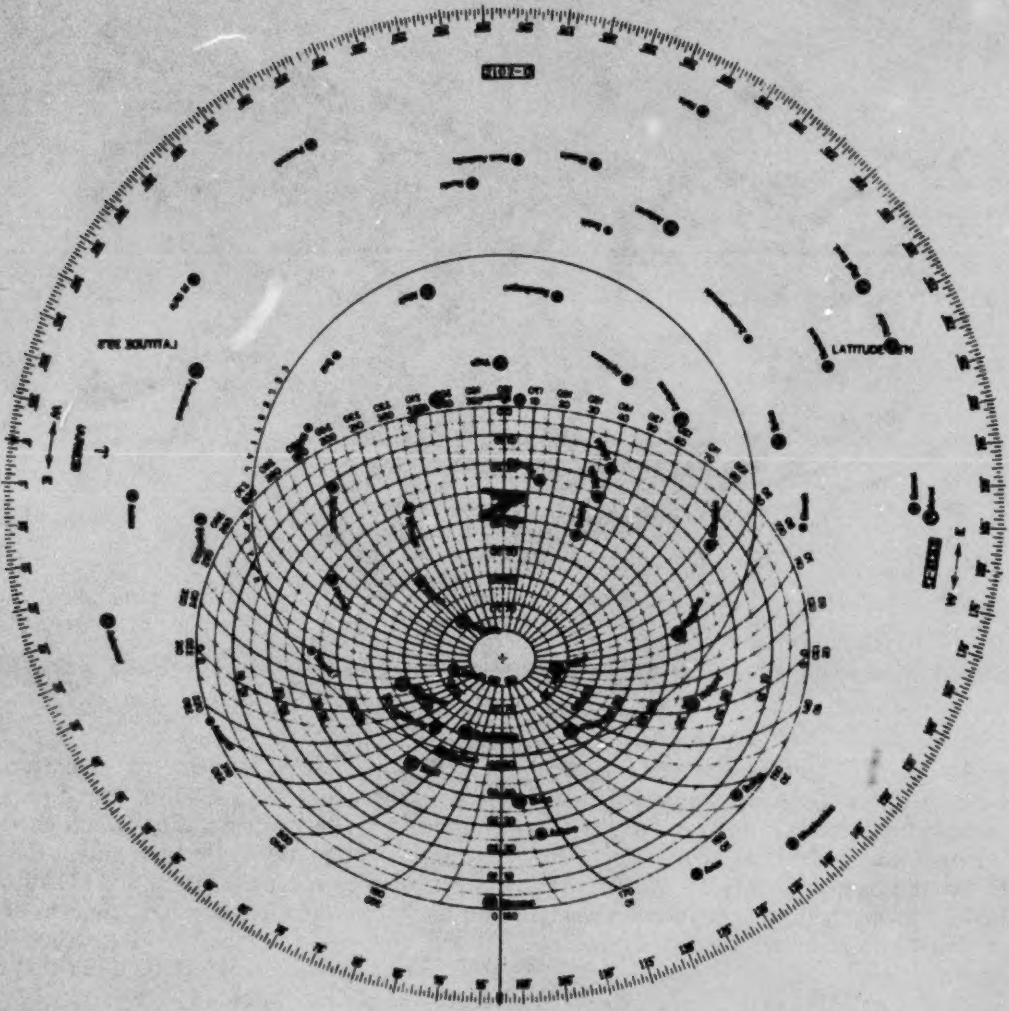
Figure 12-11.—Star base for star finder.

IDENTIFICATION OF CELESTIAL BODIES

To work a sight on a celestial body, you first must know which celestial body you have observed. Usually, before twilight, a number of bodies are selected so that the lines of position obtained will give a good fix. Identification of celestial bodies and their approximate positions at desired times can be found by using a star finder.

STAR FINDER AND IDENTIFIER METHOD

The star finder and identifier (No. 2102D) consists of a star base (figure 12-11) and nine latitude templates. The star base is a plastic disk on which the north celestial pole is at the center on one side and the south celestial pole at the center on the other side. The latitude templates are constructed for 10° latitude intervals (5°,



60.67

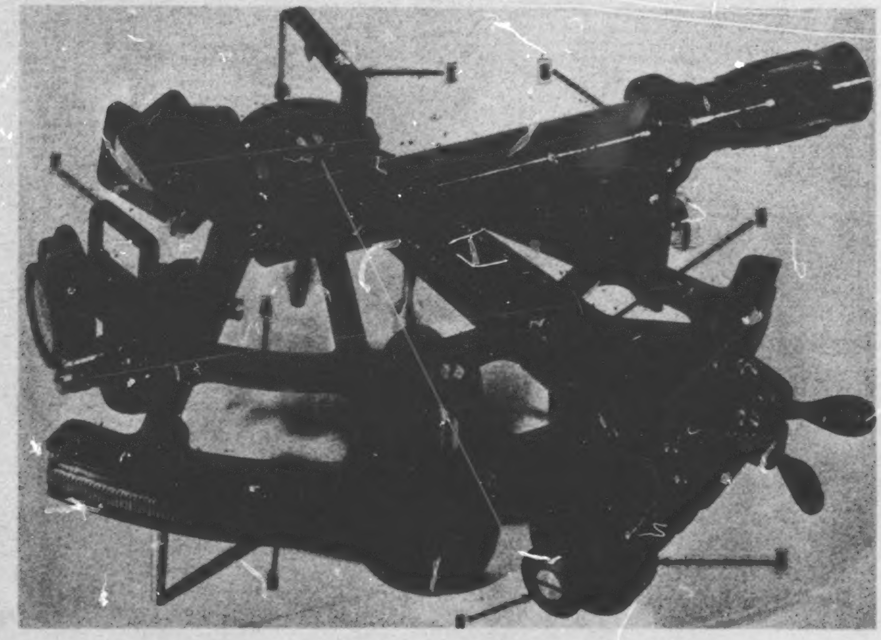
Figure 12-12.–Star base and template.

15°, 25°, etc.). Each template contains altitude and azimuth curves for determining the approximate altitudes and azimuths of celestial bodies.

Using the Star Finder

The use of the star finder is best explained by an example. Suppose you want to determine the approximate altitude and azimuth of Sirius and Rigel so that you can shoot them. Assume that you have a DR position of latitude 37°14.8′N, longitude 144°25.6′E. The GHAT is found to be 312°46.8′at that time.

To use the star finder, all you need to know is the LHA of Aries. Applying the method described earlier in this chapter, you find the LHAT to be 97°12.4′. Select the template closest to your DR latitude and place it over the star base. In this example you select the template for



29.268

Figure 12-13.—Marine sextant.

latitude 35°N and the star base, which contains N at its center. Place the template over the star base (a hole in the template fits over a peg at the center of the star base) and then orient the template so the arrow points to 97.2°. (See figure 12-12.) From the template you determine the approximate positions of Sirius and Rigel to be as follows:

	ha	Zn
Sirius	39°	176°
Rigel	43°	207°

Pub No. 249 Method

Another method of identifying stars is by consulting Vol. I of the Sight Reduction Tables for Air Navigation (Pub No. 249). In this system only selected stars are tabulated. These stars are favorably situated in azimuth and altitude for obtaining fixes.

To use the tables, the Quartermaster determines, first, the LHAT for the approximate midtime of the period during which he expects to make observations. He then enters the tables with his approximate latitude and LHAT. Listed in the tables are altitudes and azimuths of seven stars. One disadvantage of this method is that the stars tabulated may not be those that can be observed because of cloud cover.

SEXTANT

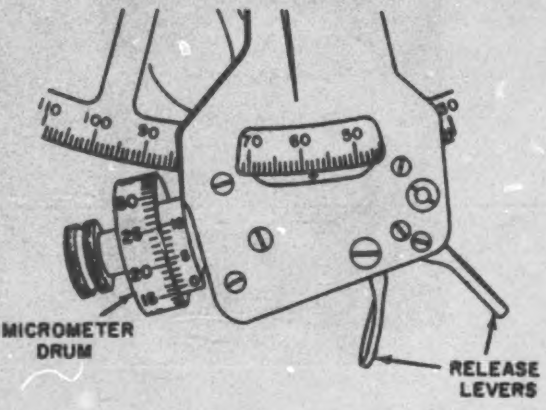
One of the better known navigational instruments is the sextant. It is used to measure angles that ultimately result in determining the ship's position at sea. The sextant is capable only of measuring the angle between two objects. Its principal function in navigation is measuring the angle (called altitude in this usage) between a heavenly body and the visible horizon. When you have the altitude, you still must work out the ship's position (by methods described later).

Figure 12-13 shows the parts of a marine sextant. Part A is the frame on which are mounted the other parts. Part B is the limb, graduated in degrees. (The word "sextant" is derived from the Latin word sex; meaning six. In old-fashioned sextants the limb was one-sixth of the arc of a circle. The limb on a modern sextant, however, contains more than one-sixth of the arc of a circle.) Part C is the index arm, which pivots about the exact center of curvature of the limb. The lower end of the arm is provided with an index mark (to indicate the reading) and with a micrometer (D). The index mirror (E) is mounted perpendicular to the plane of the limb, at the upper end of the index arm. Half of the horizon glass (F) is silvered over like a mirror; the other half is clear. At zero reading, the horizon glass is supposed to be exactly parallel to the index mirror. The telescope (G) is supported in a collar attached to the frame. It directs the observer's line of sight to the horizon glass, in a line parallel to the plane of the frame, and also magnifies the horizon. Filters reduce the glare of light reaching the eye.

MICROMETER

Figure 12-14 shows you the micrometer arrangement on a sextant. The limb on this sextant has teeth that mesh with teeth on the micrometer drum. One complete rotation of the drum moves the index arm 1° along the limb. The limb and micrometer drum can be separated by disengaging the tangent screw (part H of figure 12-13). This process is accomplished by squeezing the two small levers that project below the arm.

Looking at figure 12-14, see if you can figure out how to read the altitude. On this type of sextant, altitude can be read to the nearest tenth of a minute. It's easy to see that the altitude is somewhere between 58° and 59°—the indicator on the arm shows you that on the main scale. Inboard of the tangent screw is the micrometer drum, graduated from 0 to 60. Each graduation represents 1 minute (1′). A smaller cylinder, inboard of the drum, is graduated from 0 to 10. It is the vernier on this type of sextant. Each graduation on it represents one-tenth of a minute (0.1′). The index mark for the drum is the 0 on the vernier, which, in figure 12-14, is between 16 and 17. Thus, the altitude is a little more than 58°16′. To find, to the nearest tenth of a minute, how much more the altitude is, start along the vernier scale from 0 and locate the first graduation that lines up with a graduation on the drum. Here, it is readily apparent that the first graduation that so lines up is 3. Therefore, the sextant shows an altitude of 58°16.3′.



29.288(69)

Figure 12-14.—Marine sextant micrometer.

TAKING A SIGHT

Now that you know the parts of the sextant, let's take a Sun sight and obtain an altitude. Face the spot on the horizon just below the Sun. Place filters across the horizon glass and the index mirror, and look into the telescope. Move the sextant up or down until the line of the horizon crosses the middle of the clear half of the horizon glass. Move the arm until the index mirror picks up the Sun's image and reflects it upon the mirrored half of the horizon glass. Continue moving the arm so as to "pull down" the Sun's reflected lower limb (lower edge of the disk) until it appears to just touch the horizon, as seen through the clear half of the horizon glass. Then rock the sextant slightly from side to side so that the Sun's image describes a small arc. Adjust the arm so that the lower limb barely touches the horizon when the Sun is at the

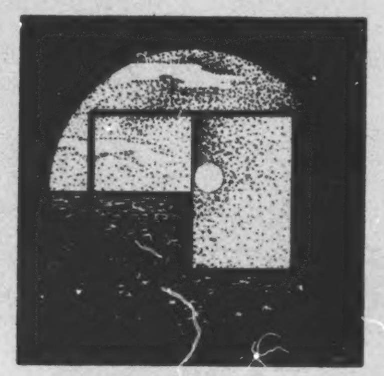


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Figure 12-15.—View through the telescope at the instant of observation.

bottom of the arc. This procedure is called "swinging the arc." It ensures that you pull the Sun's reflection to a point on the horizon directly below the Sun itself. Pulling it down to a point slightly to either side gives you an inaccurate altitude. Use the micrometer to obtain a fine adjustment and for reading the altitude to the nearest tenth of a minute. The view should appear much like figure 12-15 at the time of observation.

TIMING OBSERVATIONS

The sextant in figure 12-14 shows that the altitude of this particular heavenly body was 58°16.3′ at the instant the observation was taken. If you don't know the exact time of observation to the second, all your subsequent calculations will be inaccurate. Consequently, the exact time must be recorded the instant the observation is made. Don't wait to read the sextant altitude first.

INDEX CORRECTION

Practically every sextant has a small error, called the index error, which is allowed for by applying the index correction (IC) to every sextant reading. To find the IC, place the index mark at 0° on the limb scale, and level the sextant toward the horizon. If there is no IC, setting for zero altitude will bring the direct and reflected images of the horizon exactly into line. If the two images are not exactly in line when the instrument is set at zero, the IC is the amount shown to the right or left of zero after they are brought into line. A few graduations have been inserted to the right of the 0° mark to allow for an IC that might occur on that side.

After the images are lined up, if the index lies to the right of 0°, then the IC is plus and must be added to all sextant readings. If the index lies to the left, the IC is minus and must be subtracted.

This little jingle will help you remember how to apply the IC to the sextant reading: "When it's on, it's off; when it's off, it's on." In other words, when the reading is on the drum scale, the correction is subtractive; when the reading is off the drum scale, the correction is additive.

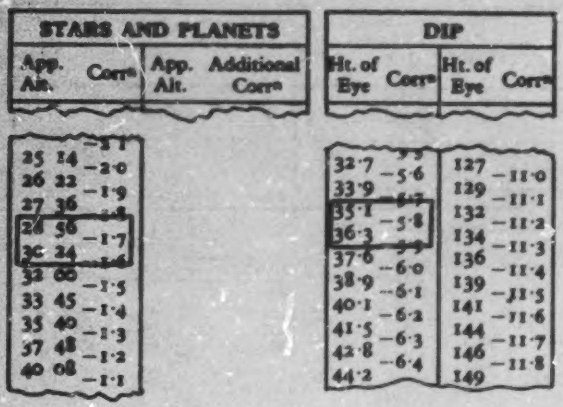
CARE OF SEXTANT

Accuracy of the sextant depends on exact adjustment and alignment of its various parts. A slight shock, for instance, can disturb the adjustment and alignment enough to produce a material error. In handling the sextant, exercise great care to avoid striking it accidentally against any object. Accidental dropping will, of course, either temporarily or permanently destroy its value as a navigational instrument. Protect it against exposure to salt spray while you are waiting to get a sight. If no shelter is available, use a towel to protect the sextant.

Moisture must not be permitted to accumulate on the mirror or glass surfaces. These surfaces should be dried with a good grade of lens paper or a piece of clean, soft linen. Silk or chamois may scratch the mirrors, and cotton cloth or waste may leave particles of lint adhering to the glass. Alcohol is an excellent glass cleaner and is safe to use on a sextant.

Never use brass polish on the arc or vernier because it eventually abrades the graduations on the scale. When cleaning becomes necessary, use ammonia. Subsequent rubbing with thin oil and lampblack will restore the distinctness of faded markings. A drop or two of light oil should be applied occasionally to the sextant's working parts.

Adjusting screws on the sextant should never be manipulated unless absolutely necessary and then only by authorized persons, who must



STARS AND PLANETS			
App. Alt.	Corrⁿ	App. Alt.	Additional Corrⁿ
	−2·1		
25 14			
	−2·0		
26 22			
	−1·9		
27 36			
	−1·8		
28 56			
	−1·7		
30 24			
	−1·6		
32 00			
	−1·5		
33 45			
	−1·4		
35 40			
	−1·3		
37 48			
	−1·2		
40 08			
	−1·1		

DIP			
Ht. of Eye	Corrⁿ	Ht. of Eye	Corrⁿ
	5·5		
32·7		127	
	−5·6		−11·0
33·9		129	
	−5·7		−11·1
35·1		132	
	−5·8		−11·2
36·3		134	
	−5·9		−11·3
37·6		136	
	−6·0		−11·4
38·9		139	
	−6·1		−11·5
40·1		141	
	−6·2		−11·6
41·5		144	
	−6·3		−11·7
42·8		146	
	−6·4		−11·8
44·2		149	

69.158

Figure 12-16.—Altitude correction table.

exercise the greatest possible caution. Minor adjustments are described in Dutton's Navigation and Piloting and Bowditch's American Practical Navigator. All other adjustments should be made by trained personnel in the optical shop.

WORKING A SIGHT

Now let's work a sight problem, using information from Pub No. 229 and the Nautical Almanac for 1970. Through use of the star finder you determine the approximate position of the celestial body you want to use (Aldebaran, for instance). Then you take a sight on Aldebaran and record the following data:

hs. . . . . 29°52.5′

GMT . . . . 21h 40m 19s 2 January 1970

DR lat. . . . . . . 34°15.0′N

DR λ. . . . . 63° 45.0′W

Height of eye . 36 feet

IC . . . . 0.8 (+)

Our first step is to find the observed altitude (Ho). From the table inside the front cover of the Nautical Almanac (figure 12-16), we learn that the correction for a 36-foot height of eye is minus 5.8′. Correction for refraction on the same page is minus 1.7′. The algebraic sum of the corrections for IC (+.8′), height of eye (-5.8′), and refraction (-1.7′) is -6.7′. Subtracting that figure from the sextant altitude (hs), we get the Ho. Thus:

hs	29°52.5′
Corrections.	-06.7′
Ho.	29°45.8′

Next, we need an assumed position (AP). To simplify matters, the latitude of the AP (DR position) is rounded off to the nearest whole degree of latitude. The DR latitude in this instance is 34°15.0′N, so we take 34°N for the latitude of the AP. For the time being we will let the longitude of the AP be the same as the DR longitude, or 63°45.0′W. Later we will see how certain requirements of convenience might cause us to alter the minutes value of the DR longitude.

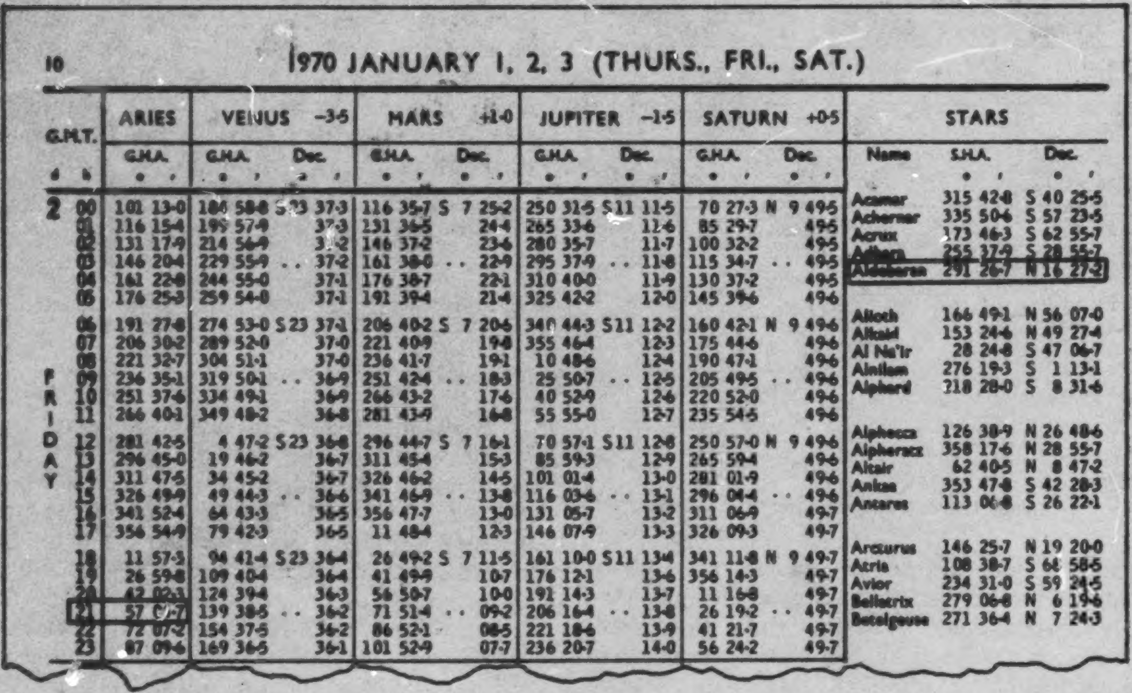
To find the computed altitude and azimuth in Pub No. 229, we need the following three values: latitude (Lat), declination (d), and local hour angle (LHA). We already have the latitude. It is assumed latitude (34°N), which is the nearest whole degree of latitude to the DR. Now let's find the declination and local hour angle.

DECLINATION

To find declination, use the appropriate daily data pages from the Nautical Almanac (figure 12-17). In the column headed STARS you can find the declination for Aldebaran. It is N (for north) 16°27.2′.

LOCAL HOUR ANGLE

Next we'll work out LHA. With stars we must determine GHA from the Nautical Almanac by adding SHA of the particular body



10 1970 JANUARY 1, 2, 3 (THURS., FRI., SAT.)

G.M.T.		ARIES	VENUS −3·5		MARS +1·0		JUPITER −1·5		SATURN +0·5		STARS		
		G.H.A.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	Name	S.H.A.	Dec.
d	h	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		° ′	° ′
2	00	101 13·0	186 58·8	S 23 37·3	116 35·7	S 7 25·2	250 31·5	S 11 11·5	70 27·3	N 9 49·5	Acamar	315 42·8	S 40 25·5
	01	116 15·4	199 57·9	37·3	131 36·5	24·4	265 33·6	11·6	85 29·7	49·5	Achernar	335 50·6	S 57 23·5
	02	131 17·9	214 56·9	37·2	146 37·2	23·6	280 35·7	11·7	100 32·2	49·5	Acrux	173 46·3	S 62 55·7
	03	146 20·4	229 55·9	· · 37·2	161 38·0	· · 22·9	295 37·9	· · 11·8	115 34·7	· · 49·5	Adhara	255 37·9	S 28 55·7
	04	161 22·8	244 55·0	37·1	176 38·7	22·1	310 40·0	11·9	130 37·2	49·5	Aldebaran	291 26·7	N 16 27·2
	05	176 25·3	259 54·0	37·1	191 39·4	21·4	325 42·2	12·0	145 39·6	49·6			
	06	191 27·8	274 53·0	S 23 37·1	206 40·2	S 7 20·6	340 44·3	S 11 12·2	160 42·1	N 9 49·6	Alioth	166 49·1	N 56 07·0
	07	206 30·2	289 52·0	37·0	221 40·9	19·8	355 46·4	12·3	175 44·6	49·6	Alkaid	153 24·6	N 49 27·4
	08	221 32·7	304 51·1	37·0	236 41·7	19·1	10 48·6	12·4	190 47·1	49·6	Al Na'ir	28 24·8	S 47 06·7
F	09	236 35·1	319 50·1	· · 36·9	251 42·4	· · 18·3	25 50·7	· · 12·5	205 49·5	· · 49·6	Alnilam	276 19·3	S 1 13·1
R	10	251 37·6	334 49·1	36·9	266 43·2	17·6	40 52·9	12·6	220 52·0	49·6	Alphard	218 28·0	S 8 31·6
I	11	266 40·1	349 48·2	36·8	281 43·9	16·8	55 55·0	12·7	235 54·5	49·6			
D	12	281 42·5	4 47·2	S 23 36·8	296 44·7	S 7 16·1	70 57·1	S 11 12·8	250 57·0	N 9 49·6	Alphecca	126 38·9	N 26 48·6
A	13	296 45·0	19 46·2	36·7	311 45·4	15·3	85 59·3	12·9	265 59·4	49·6	Alpheratz	358 17·6	N 28 55·7
Y	14	311 47·5	34 45·2	36·7	326 46·2	14·5	101 01·4	13·0	281 01·9	49·6	Altair	62 40·5	N 8 47·2
	15	326 49·9	49 44·3	· · 36·6	341 46·9	· · 13·8	116 03·6	· · 13·1	296 04·4	· · 49·6	Ankaa	353 47·8	S 42 28·3
	16	341 52·4	64 43·3	36·5	356 47·7	13·0	131 05·7	13·2	311 06·9	49·7	Antares	113 06·8	S 26 22·1
	17	356 54·9	79 42·3	36·5	11 48·4	12·3	146 07·9	13·3	326 09·3	49·7			
	18	11 57·5	94 41·4	S 23 36·4	26 49·2	S 7 11·5	161 10·0	S 11 13·4	341 11·8	N 9 49·7	Arcturus	146 25·7	N 19 20·0
	19	26 59·8	109 40·4	36·4	41 49·9	10·7	176 12·1	13·6	356 14·3	49·7	Atria	108 38·7	S 68 58·5
	20	42 02·3	124 39·4	36·3	56 50·7	10·0	191 14·3	13·7	11 16·8	49·7	Avior	234 31·0	S 59 24·5
	21	57 04·7	139 38·5	· · 36·2	71 51·4	· · 09·2	206 16·4	· · 13·8	26 19·2	· · 49·7	Bellatrix	279 06·8	N 6 19·6
	22	72 07·2	154 37·5	36·2	86 52·1	08·5	221 18·6	13·9	41 21·7	49·7	Betelgeuse	271 36·4	N 7 24·3
	23	87 09·6	169 36·5	36·1	101 52·9	07·7	236 20·7	14·0	56 24·2	49·7			

69.157

Figure 12-17.—Daily data page, Nautical Almanac.

to the tabulated GHA of the first point of Aries. Refer to the daily data pages (figure 12-17) again. Every hour of GMT for 2 January is listed in the far left column. Remember, GMT of our sight was 21h 40m 19s. We can see, then, that GHA of the first point of Aries for 21h GMT is 57°04.7′. Now we must determine how much arc to add to that to take care of the 40m 19s. From the yellow pages at the rear of the Nautical Almanac (figure 12-18) find the column headed 40m. Running down the left column to 19s and then across to the first point of Aries column, we select the value 10°06.4′. Adding this value to 57°04.7′, we get 67°11.1′, which is the GHA of Aries at the time of observation.

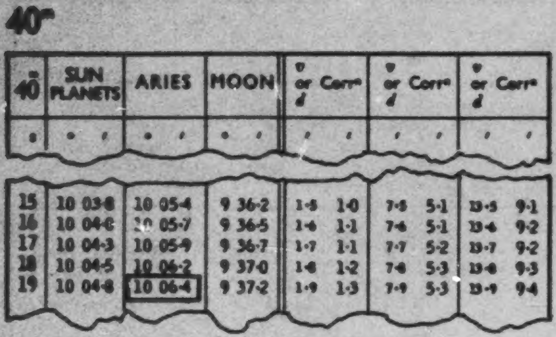
The sum of the SHA of Aldebaran and GHA of Aries equals the GHA of Aldebaran at the time of the sight. Aldebaran's SHA is found in the white pages of the Nautical Almanac under the proper date. Choosing the value 291°26.7′ from the side column opposite Aldebaran, we add:

GHA ♈	67°11.1′
SHA Aldebaran	291°26.7′
GHA Aldebaran. . . .	358°37.8′

It's obvious, now, how to solve for the local hour angle. In west longitude LHA is found by subtracting the longitude of the observer from the GHA. In east longitude LHA is found by adding the longitude of the observer to the GHA.

The longitude here is 63°45.0′ W, and we must subtract it from the GHA of Aldebaran.

GHA Aldebaran . . .	358°37.8′
λ of AP	63°37.8′
LHA	295°



40^m

40	SUN PLANETS	ARIES	MOON	v or d	Corrⁿ	v or d	Corrⁿ	v or d	Corrⁿ
s	° ′	° ′	° ′	′	′	′	′	′	′
15	10 03·8	10 05·4	9 36·2	1·5	1·0	7·5	5·1	13·5	9·1
16	10 04·0	10 05·7	9 36·5	1·6	1·1	7·6	5·1	13·6	9·2
17	10 04·3	10 05·9	9 36·7	1·7	1·1	7·7	5·2	13·7	9·2
18	10 04·5	10 06·2	9 37·0	1·8	1·2	7·8	5·3	13·8	9·3
19	10 04·8	10 06·4	9 37·2	1·9	1·3	7·9	5·3	13·9	9·4

69.158

Figure 12-18.—Increments and corrections table.

We now have the three values needed for Pub No. 229 (figure 12-19).

Latitude .... 34°00.0′N

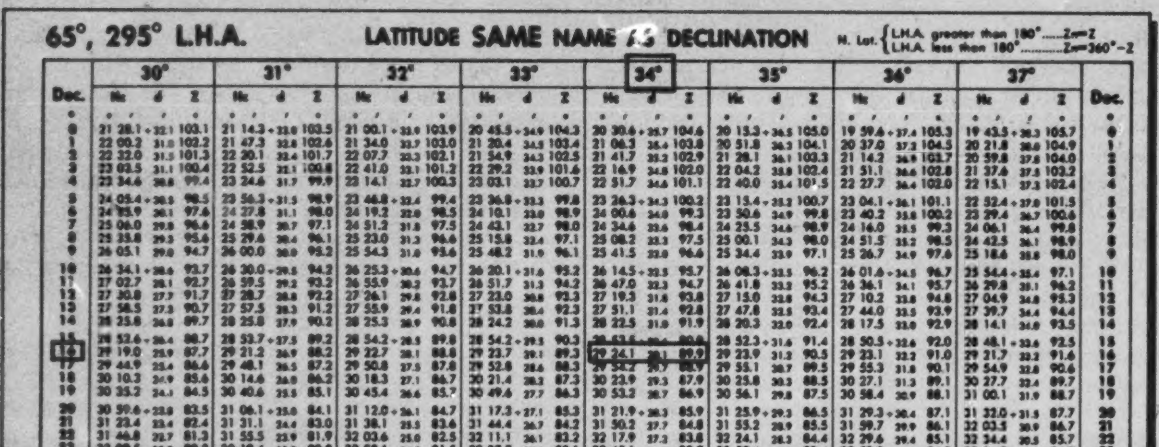
Declination ...... 16°00.0′N

Local hour angle . . 295°

COMPUTED ALTITUDE

Sight Reduction Tables for Marine Navigation Pub No. 229 is the marine or surface counterpart of Pub No. 249 and has superseded Pub No. 214. It is issued in six volumes, with one volume for each 15° band of latitude. Each volume is divided into two sections, based upon latitude, and contains tabulated altitudes and azimuths for 16° of latitude. For example, the two sections of Volume I are applicable to latitudes of 0° to 7° and 8° to 15° respectively; data pertaining to 15° latitude is also contained at the beginning of the first section of Volume II. An accuracy of 0.1′ for altitude and 0.1° for azimuth angle may be attained in calculations through the use of applicable corrections to the tabulated data.

Entering arguments are latitude, declination, and local hour angle, all in whole degrees. Although Pub No. 229 provides for entry with the exact DR latitude, the tables are intended to be entered with an assumed latitude of the nearest whole degree, and an assumed longitude which will result in a local hour angle of an integral degree. The local hour angle determines the page of entry, upon which altitude and azimuth data is tabulated in columns headed by latitude entries; vertical columns on the right



65°, 295° L.H.A. LATITUDE SAME NAME AS DECLINATION

N. Lat. {L.H.A. greater than 180°......Zn=Z; L.H.A. less than 180°..........Zn=360°−Z}

Dec.	30°			31°			32°			33°			34°			35°			36°			37°			Dec.
	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z	
°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	°
0	21 28.1	+32.1	103.1	21 14.3	+33.0	103.5	21 00.1	+33.9	103.9	20 45.5	+34.9	104.3	20 30.6	+35.7	104.6	20 15.3	+36.5	105.0	19 59.6	+37.4	105.3	19 43.5	+38.3	105.7	0
1	22 00.2	31.8	102.2	21 47.3	32.8	102.6	21 34.0	33.7	103.0	21 20.4	34.5	103.4	21 06.3	35.4	103.8	20 51.8	36.3	104.1	20 37.0	37.2	104.5	20 21.8	38.0	104.9	1
2	22 32.0	31.5	101.3	22 20.1	32.4	101.7	22 07.7	33.3	102.1	21 54.9	34.3	102.5	21 41.7	35.2	102.9	21 28.1	36.1	103.3	21 14.2	36.9	103.7	20 59.8	37.8	104.0	2
3	23 03.5	31.1	100.4	22 52.5	32.1	100.8	22 41.0	33.1	101.2	22 29.2	33.9	101.6	22 16.9	34.8	102.0	22 04.2	35.8	102.4	21 51.1	36.6	102.8	21 37.6	37.5	103.2	3
4	23 34.6	30.8	99.4	23 24.6	31.7	99.9	23 14.1	32.7	100.3	23 03.1	33.7	100.7	22 51.7	34.6	101.1	22 40.0	35.4	101.5	22 27.7	36.4	102.0	22 15.1	37.3	102.4	4
5	24 05.4	+30.5	98.5	23 56.3	+31.5	98.9	23 46.8	+32.4	99.4	23 36.8	+33.3	99.8	23 26.3	+34.3	100.2	23 15.4	+35.2	100.7	23 04.1	+36.1	101.1	22 52.4	+37.0	101.5	5
6	24 35.9	30.1	97.6	24 27.8	31.1	98.0	24 19.2	32.0	98.5	24 10.1	33.0	98.9	24 00.6	34.0	99.3	23 50.6	34.9	99.8	23 40.2	35.8	100.2	23 29.4	36.7	100.6	6
7	25 06.0	29.8	96.6	24 58.9	30.7	97.1	24 51.2	31.8	97.5	24 43.1	32.7	98.0	24 34.6	33.6	98.4	24 25.5	34.6	98.9	24 16.0	35.5	99.3	24 06.1	36.4	99.8	7
8	25 35.8	29.3	95.6	25 29.6	30.4	96.1	25 23.0	31.3	96.6	25 15.8	32.4	97.1	25 08.2	33.3	97.5	25 00.1	34.3	98.0	24 51.5	35.2	98.5	24 42.5	36.1	98.9	8
9	26 05.1	29.0	94.7	26 00.0	30.0	95.2	25 54.3	31.0	95.6	25 48.2	31.9	96.1	25 41.5	33.0	96.6	25 34.4	33.9	97.1	25 26.7	34.9	97.6	25 18.6	35.8	98.0	9
10	26 34.1	+28.6	93.7	26 30.0	+29.5	94.2	26 25.3	+30.6	94.7	26 20.1	+31.6	95.2	26 14.5	+32.5	95.7	26 08.3	+33.5	96.2	26 01.6	+34.5	96.7	25 54.4	+35.4	97.1	10
11	27 02.7	28.1	92.7	26 59.5	29.2	93.2	26 55.9	30.2	93.7	26 51.7	31.3	94.2	26 47.0	32.3	94.7	26 41.8	33.2	95.2	26 36.1	34.1	95.7	26 29.8	35.1	96.2	11
12	27 30.8	27.7	91.7	27 28.7	28.8	92.2	27 26.1	29.8	92.8	27 23.0	30.8	93.3	27 19.3	31.8	93.8	27 15.0	32.8	94.3	27 10.2	33.8	94.8	27 04.9	34.8	95.3	12
13	27 58.5	27.3	90.7	27 57.5	28.3	91.2	27 55.9	29.4	91.8	27 53.8	30.4	92.3	27 51.1	31.4	92.8	27 47.8	32.5	93.4	27 44.0	33.5	93.9	27 39.7	34.4	94.4	13
14	28 25.8	26.8	89.7	28 25.8	27.9	90.2	28 25.3	28.9	90.8	28 24.2	30.0	91.3	28 22.5	31.0	91.9	28 20.3	32.0	92.4	28 17.5	33.0	92.9	28 14.1	34.0	93.5	14
15	28 52.6	+26.4	88.7	28 53.7	+27.5	89.2	28 54.2	+28.5	89.8	28 54.2	+29.5	90.3	[illegible]	[illegible]	[illegible]	28 52.3	+31.6	91.4	28 50.5	+32.6	92.0	28 48.1	+33.6	92.5	15
16	29 19.0	25.9	87.7	29 21.2	26.9	88.2	29 22.7	28.1	88.8	29 23.7	29.1	89.3	29 24.1	30.1	89.9	29 23.9	31.2	90.5	29 23.1	32.2	91.0	29 21.7	33.2	91.6	16
17	29 44.9	25.4	86.6	29 48.1	26.5	87.2	29 50.8	27.5	87.8	29 52.8	28.6	88.3	29 54.2	29.7	88.9	29 55.1	30.7	89.5	29 55.3	31.8	90.1	29 54.9	32.8	90.6	17
18	30 10.3	24.9	85.6	30 14.6	26.0	86.2	30 18.3	27.1	86.7	30 21.4	28.2	87.3	30 23.9	29.3	87.9	30 25.8	30.3	88.5	30 27.1	31.3	89.1	30 27.7	32.4	89.7	18
19	30 35.2	24.4	84.5	30 40.6	25.5	85.1	30 45.4	26.6	85.7	30 49.6	27.7	86.3	30 53.2	28.7	86.9	30 56.1	29.8	87.5	30 58.4	30.9	88.1	31 00.1	31.9	88.7	19
20	30 59.6	+23.8	83.5	31 06.1	+25.0	84.1	31 12.0	+26.1	84.7	31 17.3	+27.1	85.3	31 21.9	+28.3	85.9	31 25.9	+29.3	86.5	31 29.3	+30.4	87.1	31 32.0	+31.5	87.7	20
21	31 23.4	23.4	82.4	31 31.1	24.4	83.0	31 38.1	25.5	83.6	31 44.4	26.7	84.2	31 50.2	27.7	84.8	31 55.2	28.9	85.5	31 59.7	29.9	86.1	32 03.5	30.9	86.7	21
22	31 46.8	22.7	81.3	31 55.5	23.9	81.9	32 03.6	25.0	82.5	32 11.1	26.1	83.2	32 17.9	27.2	83.8	32 24.1	28.3	84.4	32 29.6	29.4	85.1	32 34.4	30.5	85.7	22
23	32 09.5	22.2	80.2	[illegible]	[illegible]	80.8	32 28.6	24.5	81.5	32 37.2	[illegible]	82.1	[illegible]	26.7	82.7	32 52.4	[illegible]	83.4	32 59.0	[illegible]	84.0	[illegible]	30.0	84.7	[illegible]

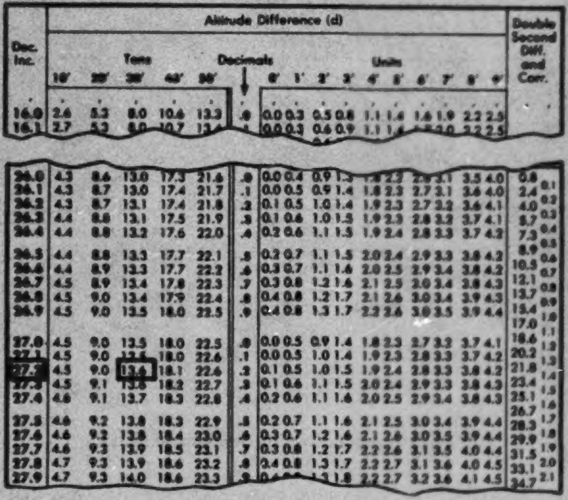
69.159

Figure 12-19.—Page of Pub. No. 229.

and left margins of each page provide for the declination entry. For each entry of LHA, the lefthand page provides tabulations for latitude and declination of the same name. The right-hand page, upper portion, provides for latitude and declination of contrary name; the lower portion of the right-hand page is a continuation of the page to the left and contains tabulations for latitude and declination of the same name, as applicable to values of LHA in excess of 90° but less than 270°.

As in the use of Pub No. 249, the declination entry is the nearest tabulated value which is equal to or numerically less than the actual declination. To the right of each tabulated altitude, under a column subheaded as "d", is the incremental change in altitude based upon a declination increase of 1°, together with sign. An interpolation table is conveniently included (figure 12-20) and is entered with the declination increase (difference between the actual declination and the declination integer used as an argument of entry) and the altitude difference (d). The interpolation table is entered in two steps. In the first, the declination increase and even tens of minutes of altitude difference (d) are used; in the second, the declination increase and the remaining altitude difference (d) in minutes and tenths of minutes are used to find the correction to altitude. In this step, decimals (tenths) may be found as a vertical argument. Values found in these two steps are combined and applied to the tabulated altitude in accordance with the sign of altitude difference (d). This is the first of two procedures known as difference corrections.

For greater precision, a second difference correction is sometimes appropriate. When this is the case, the value of d is printed in Pub No. 229 in italics and is followed by a dot. The second difference is found by comparing the altitude differences above and below the base value; for example, if the declination argument for entry is 20°, the altitude difference values for 19° and 21° are compared, and the difference between the two is the double second difference. Interpolation tables contain, on their right-hand edge, a double column which is identified as a double second difference and correction column; this is a critical table and correction values are taken directly from it. The



Dec. Inc.	Altitude Difference (d)																Double Second Diff. and Corr.	
	Tens					Decimals	Units											
	10'	20'	30'	40'	50'	↓	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'		
'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'	'
16.0	2.6	5.3	8.0	10.6	13.3	.0	0.0	0.3	0.5	0.8	1.1	1.4	1.6	1.9	2.2	2.5		
16.1	2.7	5.3	8.0	10.7	13.4	.1	0.0	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.2	2.5		
26.0	4.3	8.6	13.0	17.3	21.6	.0	0.0	0.4	0.9	1.3	1.8	2.2	2.6	3.1	3.5	4.0	0.8	
																		0.1
26.1	4.3	8.7	13.0	17.4	21.7	.1	0.0	0.5	0.9	1.4	1.8	2.3	2.7	3.1	3.6	4.0	2.4	
																		0.2
26.2	4.3	8.7	13.1	17.4	21.8	.2	0.1	0.5	1.0	1.4	1.9	2.3	2.7	3.2	3.6	4.1	4.0	
																		0.3
26.3	4.4	8.8	13.1	17.5	21.9	.3	0.1	0.6	1.0	1.5	1.9	2.3	2.8	3.2	3.7	4.1	5.7	
																		0.4
26.4	4.4	8.8	13.2	17.6	22.0	.4	0.2	0.6	1.1	1.5	1.9	2.4	2.8	3.3	3.7	4.2	7.3	
																		0.5
26.5	4.4	8.8	13.3	17.7	22.1	.5	0.2	0.7	1.1	1.5	2.0	2.4	2.9	3.3	3.8	4.2	8.9	
																		0.6
26.6	4.4	8.9	13.3	17.7	22.2	.6	0.3	0.7	1.1	1.6	2.0	2.5	2.9	3.4	3.8	4.2	10.5	
																		0.7
26.7	4.5	8.9	13.4	17.8	22.3	.7	0.3	0.8	1.2	1.6	2.1	2.5	3.0	3.4	3.8	4.3	12.1	
																		0.8
26.8	4.5	9.0	13.4	17.9	22.4	.8	0.4	0.8	1.2	1.7	2.1	2.6	3.0	3.4	3.9	4.3	13.7	
																		0.9
26.9	4.5	9.0	13.5	18.0	22.5	.9	0.4	0.8	1.3	1.7	2.2	2.6	3.0	3.5	3.9	4.4	15.4	
																		1.0
																	17.0	
																		1.1
27.0	4.5	9.0	13.5	18.0	22.5	.0	0.0	0.5	0.9	1.4	1.8	2.3	2.7	3.2	3.7	4.1	18.6	
																		1.2
27.1	4.5	9.0	13.5	18.0	22.6	.1	0.0	0.5	1.0	1.4	1.9	2.3	2.8	3.3	3.7	4.2	20.2	
																		1.3
27.2	4.5	9.0	13.6	18.1	22.6	.2	0.1	0.5	1.0	1.5	1.9	2.4	2.8	3.3	3.8	4.2	21.8	
																		1.4
27.3	4.5	9.1	13.6	18.2	22.7	.3	0.1	0.6	1.1	1.5	2.0	2.4	2.9	3.3	3.8	4.3	23.4	
																		1.5
27.4	4.6	9.1	13.7	18.3	22.8	.4	0.2	0.6	1.1	1.6	2.0	2.5	2.9	3.4	3.8	4.3	25.1	
																		1.6
																	26.7	
																		1.7
27.5	4.6	9.2	13.8	18.3	22.9	.5	0.2	0.7	1.1	1.6	2.1	2.5	3.0	3.4	3.9	4.4	28.3	
																		1.8
27.6	4.6	9.2	13.8	18.4	23.0	.6	0.3	0.7	1.2	1.6	2.1	2.6	3.0	3.5	3.9	4.4	29.9	
																		1.9
27.7	4.6	9.3	13.9	18.5	23.1	.7	0.3	0.8	1.2	1.7	2.2	2.6	3.1	3.5	4.0	4.4	31.5	
																		2.0
27.8	4.7	9.3	13.9	18.6	23.2	.8	0.4	0.8	1.3	1.7	2.2	2.7	3.1	3.6	4.0	4.5	33.1	
																		2.1
27.9	4.7	9.3	14.0	18.6	23.3	.9	0.4	0.9	1.3	1.8	2.2	2.7	3.2	3.6	4.1	4.5	34.7	

69.160

Figure 12-20.—Interpolation table.

second difference correction is always additive. As appropriate, first and second difference corrections are obtained, combined, and applied to the tabulated altitude to determine computed altitude.

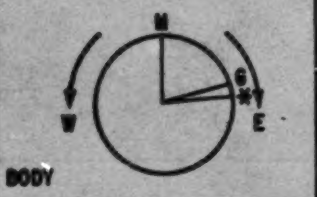
Pub No. 229 tabulates, following altitude difference (d), the azimuth angle (Z) to the nearest tenth of a degree. For greater accuracy, mental interpolation may be used, not only to correct the azimuth angle for the declination increase or difference, but also for differences in latitude and LHA. Rules are given on each page of Pub No. 229 for conversion of azimuth angle (Z) to true azimuth (Zn).

Table 12-1 illustrates sight reduction for the star Aldebaran using Pub No. 229.

AIR NAVIGATION TABLES

Sight Reduction Tables for Air Navigation (Pub No. 249) contains another system for solving sights and obtaining lines of position—a system that is becoming increasingly popular in the fleet. The tables come in three volumes and are arranged for use with the Air Almanac.

Table 12-1.–Complete solution for Aldebaran

Local Date 2 JAN 1970 Course 060° Speed 15 kts Body Aldebaran					
DR:	Lat	34	15N		
	Long	63	45W		
ZT		1740-19			
ZD		+4			
GMT		2140-19			
Gr Date		2 JAN			
GHA (hrs)		57	04.7		
GHA (m & s)		10	06.4		
v corr or SHA		291	26.7		
Total GHA		358	37.8		
a Long		63	37.8		E [✓ W]
LHA		295			
Dec Tab		16	27.2		[✓ N] S
d. corr (±)		( )			
Total Dec.		16	27.2		[✓ N] S
Enter Pub. No. 229	LHA	295			
	Dec	16			[✓ N] S
	a Lat	34			[✓ N] S
Dec Inc	(±) d	27.2		30.1	
tens	DS diff	30		13.6	
units	DS corr	.1		+00	
Total corr (±)				13.6	
Hc (tab Alt)		29		24.1	
HC		29		37.7	
Sext. Corr.		+		-	
I.C.		0.8			
Dip (36 ft)				5.8	
Main Corr				1.7	
Add'l					
SUMS		0.8		7.5	
Corr				-6.7	
Hs		29		52.5	
Ho		29		45.8	
Hc		29		37.7	
a				8.1A	[✓ T]
Az (interpolate)			089.4		
Zn			089.4		
Advance					

190.33

Volume I contains data for selected stars. This volume is usable through all degrees of latitude from 89°N to 89°S. As explained previously, this volume also serves as a star finder and identifier for a number of stars.

After observing a body, sextant altitude corrections are applied in the usual manner to obtain Ho. An assumed longitude(aλ) is selected so that LHA of Aries will be a whole degree (or an even degree above 69° latitude). The tables are entered, using the nearest whole degree of latitude, LHA♈, and the name of the body. The computed altitude and azimuth are extracted. For complete details of this method, you are advised to consult the instructions in Volume I. Volumes II and III seldom are used in surface navigation.

LOCAL APPARENT NOON

Local apparent noon (LAN) is a sight taken on the Sun the instant it transits an observer's meridian. At that time the Sun is at its highest altitude. The LAN lines of position coincide with the ship's latitude.

A number of methods for determining the time of LAN have been devised, but the one given here probably is the simplest. It consists of considering the GHA of the Sun to be equal to the ship's longitude, when in west longitude, or 360° minus the ship's longitude when in east longitude.

The largest tabulated value for GHA of the Sun that does not exceed the longitude is extracted from the daily page of the Nautical Almanac. The difference between this tabulated GHA and the assumed longitude is then used to enter the Increments and Corrections table in the yellow pages at the back of the Nautical Almanac. The time interval corresponding to this value is added to the time of GHA taken from the daily page, and the sum of these two values represents the time of LAN (The Increments and Corrections table is used here to convert arc to time.) A problem of LAN involving a ship in west longitude would be worked as follows:

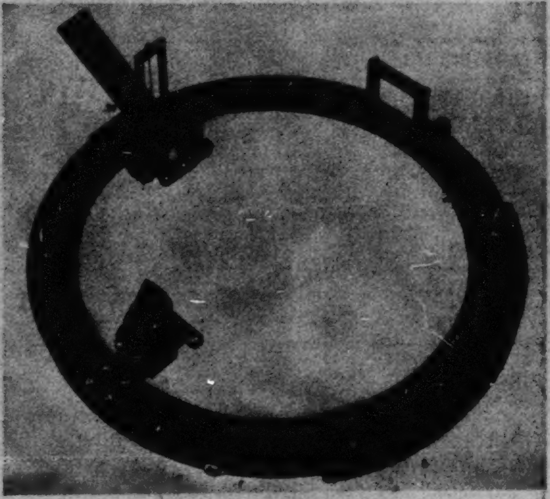
Required	Source	Solution
Date	Always know	31 May 1966
a λ	Taken from DR position	156°44.3′W
GHA of Sun	Daily page of almanac	150°36.3′
Time	Opposite time of GHA	22h
Increment	Difference between λ and GHA of Sun	6°08.0′
Correction	Increments and correction table	24m 32s
GMT on LAN	Time plus correction	22h 24m 32s
Zone difference	Local time correction	10h
LMT of LAN	GMT minus zone difference	12h 24m 32s

In the preceding problem, LAN would occur at approximately 1225. A closer estimate can be obtained by taking the difference between the 1200 and the 1225 DR longitudes, coverting that difference to time, and applying the resulting correction to the previously determined time of LAN.

Now that LAN is known to the closest minute, the usual procedure is to start taking sights of the Sun a few minutes early to ensure that a sight actually is taken at the exact instant of transit.

AZIMUTH OF THE SUN

Computation of compass error at sea depends upon the observation of the azimuth of celestial bodies; the Sun is the most commonly used for this purpose. Upon observation, the observed azimuth is recorded. The time (to the nearest second) and the DR position are also noted. With DR position and time, the navigator computes Zn. The difference between GB (gyro bearing) and Zn (true direction) is compass error (C.E.). It should be appropriately labeled. Keep in mind that accuracy depends upon the navigator's knowledge of his position and the correct time.



65.122

Figure 12-21.—Azimuth circle.

In taking an azimuth of a celestial body, the azimuth circle is used. An azimuth circle (figure 12-21) is a nonmagnetic metal ring sized to fit upon a 7½-inch compass bowl or upon a gyro repeater. The inner lip is graduated in degrees from 0 to 360 in a counterclockwise direction for the purpose of taking relative bearings. Two sighting vanes (the forward or far vane containing a vertical wire, and the after or near vane containing a peep sight) facilitate the observation of bearings and azimuths. Two finger lugs are used to position the instrument exactly while aligning the vanes. A hinged reflector vane mounted at the base and beyond the forward vane is used for reflecting stars and planets when observing azimuths. Beneath the forward vane a reflecting mirror and the extended vertical wire are mounted, enabling the navigator to read the bearing or azimuth from the reflected portion of the compass card. For

EXAMPLE (PUB. NO. 229)

DATE 2 JAN 1970	GB 227.5
** DR LAT 33°12'N	DR LONG 21°22'W
ZT	1554 12
ZD (+W) (−E)	+1
GMT	1654 12
GR DATE	2 JAN 1970
GHA (hrs)	58 59.0
GHA (m & s)	13 33.0
TOTAL GHA	72 32.0
DR LONG (+E) (−W)	21 22.0
** LHA	51 10.0
TAB DEC	22 55.0
d CORR (.2) ±	.2
TOTAL DEC	22 54.8

(CORR = FACTOR x AZ DIFF)

	EXACT	LOWEST TAB	FACTOR	AZ TAB	AZ INTER'P	AZ DIFF	CORR	
							+	−
DEC	22 54.8	22	$\frac{54.8}{60} = .7$	131.3	132.0	+.7	.64	
DR LAT	33 12.0	33	$\frac{12}{60} = .2$	131.3	131.5	+.2	.04	
LHA	51 10.0	51	$\frac{10}{60} = .8$	131.3	130.5	−.8		.13

TOTAL CORR +.55 or .6

AZ TAB	131.3
CORR	+.6
** AZ	N 131.9 W
	360.0 −131.9
ZN	228.1
GB	227.5
GE	.6 E

** CONVERT AZ TO ZN

NORTH LAT
LHA GREATER THAN 180°.. ZN = AZ
LHA LESS THAN 180°....... ZN = 360° − AZ

SOUTH LAT
LHA GREATER THAN 180°... ZN = 180° − AZ
LHA LESS THAN 180° .... ZN = 180° + AZ

COMPASS BEST ERROR WEST
COMPASS LEAST ERROR EAST

69.162

Figure 12-22.—Sample azimuth problem.

observing azimuths of the Sun, an additional reflecting mirror and housing are mounted on the ring, each midway between the forward and after vanes. The Sun's rays are reflected by the mirror to the housing where a vertical slit admits a line of light. This admitted light passes through a 45° reflecting prism and is projected on the compass card from which the azimuth is directly read. In observing both bearings and azimuths, two spirit levels, which are attached, must be used to level the instrument.

Use figure 12-22 and the 15 steps to solve the sample problem:

On 2 Jan 1970, the navigator observes the Sun with an azimuth circle and gets byro bearing of 227.5°. The exact time of observation was 15-54-12. His 1554 DR position was 33°12.0'N, 21°22.0'W.

1. Record known information on form.
2. Find ZD, GMT, and date.
3. Determine the GHA and declination of the Sun for time of observation (same as sight form).
4. Apply the DR longitude to the GHA and determine the exact LHA of the Sun.

   a. In some cases you must add 360° to the GHA to subtract DR longitude.

5. Record the three exact values, (LHA, DEC, and DR lat.).

   a. Record the three lowest tab values of above. (These are the base entering arguments into Pub No. 229.)

6. Determine the factors for the minutes of each of the three entering arguments by dividing the minutes of each by 60 and rounding off to the nearest tenth.

7. Using the lowest tab values of the three entering arguments, enter Pub No. 229 and determine the Az Tab.

8. Determine the AZ on the other side of the exact values for each of the three arguments and record it under AZ Inter'p.

9. Determine the AZ difference along with sign between the AZ Tab and AZ Inter'p.

10. Multiply the factor and the AZ difference for each argument and record it to nearest tenth in appropriate plus or minus column.

11. Add the three corrections and determine the total correction.

12. Apply the total correction to the AZ Tab to determine the AZ.

13. Convert the AZ to Zn, according to rules on form.

14. Compare the GB and the Zn to determine the amount of gyro error.

15. Determine the direction of the gyro error.

CHAPTER 13

TIDES AND CURRENTS

Several problems posed by tides and currents can be solved by means of tide and current tables. By using Tide Tables the height of tides can be found at any time. Tidal Current Tables permit a similar type of calculation in determining set and drift of the current at any time. Other calculations pertaining to sunrise, sunset, moonrise, and moonset can also be made from data in these tables. Additional publications also contain sunrise/sunset and moonrise/moonset calculations. The Nautical Almanac and Air Almanac are two such publications. This chapter discusses problems dealt with in the aforementioned four publications and explains the methods utilized in solving the problems.

TIDES

The vertical rise and fall of the ocean level, caused by the gravitational pull of the Moon and Sun acting in conjunction with the centrifugal force of the rotating Earth, is called tide. The highest level reached by an ascending tide is called high water; the lowest level of a descending tide, low water. At high and low water there is a brief period during which no change occurs in the water level. This period is called stand.

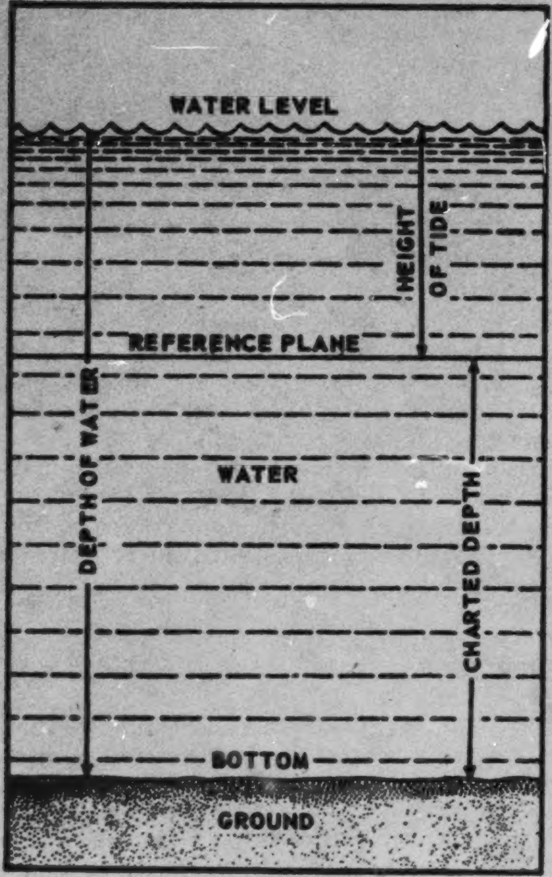
The total rise or fall from low water to high, or vice versa, is called the range of the tide. The actual height of the water level at high and low water differs with phases of the Moon, variations of wind force and directions, and other phenomena. The average height of high water, measured over a 19-year period, is called mean high water. The average height of low water, measured over the same period, is mean low water. The plane midway between mean high and mean low water is mean tide level.

Spring tides occur near the time of full Moon and new Moon, at which times the Sun and Moon act together to produce tides higher and lower than average. When the Moon is in its first or last quarter, the Moon and the Sun are opposed to each other, high tides are lower and low tides are higher than usual and are referred to as neap tides.

TIME OF TIDE AND DEPTH OF WATER

You already are familiar with the tiny figures that indicate depth of water on a chart. Let's look at one of them—a 6, for instance. On the chart, check under the title "Soundings in Fathoms at Mean Low Water." Does this figure 6 mean that there always are exactly 6 fathoms at low water at this particular spot? No. Mean low water is only an average of the various depths actually sounded here at low water during survey. Consequently, the actual water level at low water may be above or below mean low water at different times. Height of tide, then, does not refer to actual depth of water. Nor does the charted depth, shown by one of the small figures on the chart, indicate the lowest depth to be found at all times at that particular point.

Figure 13-1 shows you the relationship of certain tidal terms to water depth. The charted depth is the vertical distance from the reference plane to the ocean bottom. (Usually soundings are based on mean low water.) As you have seen, the actual depth of water can be less than the charted depth, or below the reference plane. This depth is indicated by a minus sign placed



65.131

Figure 13-1.—Relationship of terms to water depth.

before the height of tide shown in the tide tables. The depth of water is equal to the algebraic sum of the charted depth and the height of tide.

Usually two high tides and two low tides occur each lunar day. Because of the changing relative positions of the Sun and Moon with respect to the Earth and to each other, an infinite variety of tidal situations is possible. Thus, the height of the water level varies from tide to tide and from day to day. The lower of the two low tides in any one tidal day is called lower low water.

TIDE TABLES

When a ship is making port, the navigator must know the minimum depth of water through which the ship will pass. Depth varies, of course, with phases of the tide. Some ports must be entered over bars or shoals, which some seagoing vessels cannot transit except during high water.

Depth of water at anchorages must also be known in order to determine proper scope of chain. Information to this effect is obtained from Tide Tables, published annually by the National Ocean Survey. There are four volumes of Tide Tables, covering the following areas: East Coast of North and South America (including Greenland); West Coast of North and South America (including the Hawaiian Islands); Central and Western Pacific Ocean and Indian Ocean.

The time and height of tide at each high and low water are listed in the Tide Tables for a number of principal locations, called reference stations. Table 1 of the Tide Tables (table 13-1) illustrates the listing for one such reference station, New York City at the Battery. Because the lunar or tidal day is a little more than 24 hours in length (it averages about 24h 50m), the time between successive high or low tides is a little more than 12 hours. When a high or low tide occurs just before midnight, the next high or low tide occurs approximately at noon on the following day; the next, just after the ensuing midnight. Only under these conditions do three consecutive high or low tides occur on three different dates. The total interval is no longer than the period of a lunar day. This interval means that on the middle day of the three, there is but one high or low water.

Table 2 of the Tide Tables (table 13-2) contains a list of secondary or subordinate stations. Location (latitude or longitude) of each station is given, together with certain information which, when applied to predictions for the stated reference station, gives tidal data for the subordinate station. Usually a time difference is included, and it is added to or subtracted from the time of the reference station. Quartermasters must be alert for changes in date when applying the time difference.

Table 13-1.—Height of Tide at Reference Station

90

NEW YORK (THE BATTERY), N.Y., 1975

TIMES AND HEIGHTS OF HIGH AND LOW WATERS

	JULY						AUGUST						SEPTEMBER				
DAY	TIME	HT.	DAY	TIME	HT.	DAY	TIME	HT.	DAY	TIME	HT.	DAY	TIME	HT.	DAY	TIME	HT.
	H.M.	FT.		H.M.	FT.		H.M.	FT.		H.M.	FT.		H.M.	FT.		H.M.	FT.
1	0114	4.0	16	0154	4.5	1	0148	3.7	16	0341	4.1	1	0336	3.9	16	0521	4.3
TU	0737	0.7	W	0815	0.1	F	0818	1.0	SA	0959	0.5	M	1007	0.8	TU	1126	0.5
	1358	4.2		1435	5.2		1436	4.5		1614	5.0		1611	4.9		1742	4.8
	2027	1.2		2108	0.4		2143	1.1		2246	0.4		2300	0.5		2357	0.2
2	0156	3.8	17	0255	4.3	2	0251	3.6	17	0446	4.1	2	0449	4.2	17	0611	4.5
W	0834	0.8	TH	0918	0.2	SA	0934	0.9	SU	1054	0.5	TU	1106	0.5	W	1212	0.4
	1442	4.3		1533	5.2		1540	4.7		1713	5.1		1716	5.2		1826	4.9
	2126	1.1		2205	0.3		2238	0.8		2337	0.3		2350	0.1			
3	0245	3.7	18	0401	4.1	3	0409	3.7	18	0545	4.2	3	0548	4.7	18	0040	0.1
TH	0930	0.8	F	1015	0.2	SU	1033	0.7	M	1146	0.4	W	1203	0.1	TH	0655	4.7
	1538	4.4		1634	5.2		1645	4.9		1806	5.2		1811	5.5		1257	0.3
	2220	0.9		2305	0.2		2329	0.5								1907	5.0
4	0348	3.6	19	0505	4.1	4	0518	4.0	19	0025	0.1	4	0039	-0.3	19	[illegible]	0.0
F	1017	0.7	SA	1110	0.2	M	1127	0.5	TU	0636	4.4	TH	0641	5.1	F	[illegible]	4.9
	1629	4.6		1733	5.3		1742	5.2		1235	0.3		1255	-0.3		1338	0.2
	2311	0.7		2358	0.1					1851	5.2		1902	5.7		1946	5.0
5	0434	3.7	20	0602	4.2	5	0019	0.1	20	0110	0.0	5	0127	-0.6	20	0201	0.0
SA	1106	0.6	SU	1202	0.2	TU	0615	4.3	W	0719	4.6	F	0730	5.5	SA	0807	5.0
	1723	4.9		1825	5.4		1222	0.2		1321	0.2		1348	-0.6		1419	0.1
							1833	5.5		1933	5.2		1949	5.9		2021	4.9
6	0001	0.4	21	0048	-0.1	6	0109	-0.2	21	0151	-0.1	6	0214	-0.8	21	0236	0.0
SU	0530	3.9	M	0653	4.3	W	0706	4.7	TH	0758	4.7	SA	0819	5.8	SU	0840	5.0
	1156	0.4		1253	0.1		1313	-0.1		1405	0.2		1437	-0.7		1457	0.1
	1811	5.2		1912	5.4		1923	5.8		2012	5.2		2039	5.8		2054	4.7
7	0048	0.1	22	0134	-0.2	7	0155	-0.5	22	0231	-0.1	7	0300	-0.9	22	0309	0.1
M	0643	4.1	TU	0739	4.5	TH	0755	5.1	F	0837	4.8	SU	0910	5.9	M	0913	4.9
	1245	0.2		1341	0.1		1406	-0.3		1444	0.2		1527	-0.7		1531	0.2
	1857	5.5		1955	5.4		2011	5.9		2049	5.1		2131	5.6		2124	4.5
8	0136	-0.2	23	0218	-0.2	8	0241	-0.8	23	0307	-0.1	8	0345	-0.8	23	0337	0.2
TU	0730	4.4	W	0825	4.5	F	0843	5.3	SA	0915	4.8	M	1003	5.9	TU	0942	4.9
	1335	0.0		1425	0.2		1456	-0.5		1522	0.3		1616	-0.6		1606	0.4
	1943	5.6		2036	5.3		2100	5.8		2123	4.9		2227	5.3		2155	4.3
9	0221	-0.5	24	0258	-0.2	9	0325	-0.9	24	0341	0.0	9	0431	-0.6	24	0403	0.4
W	0816	4.6	TH	0907	4.5	SA	0934	5.5	SU	0952	4.7	TU	1059	5.8	W	1012	4.8
	1424	-0.1		1507	0.2		1544	-0.5		1557	0.4		1707	-0.3		1635	0.5
	2029	5.7		2116	5.1		2152	5.7		2157	4.7		2324	5.0		2222	4.1
10	0306	-0.6	25	0337	-0.2	10	0410	-0.8	25	0411	0.2	10	0520	-0.2	25	0422	0.6
TH	0906	4.8	F	0949	4.5	SU	1029	5.6	M	1027	4.7	W	1154	5.6	TH	1043	4.7
	1511	-0.2		1546	0.4		1634	-0.4		1629	0.6		1806	0.1		1704	0.7
	2116	5.7		2155	4.9		2248	5.4		2229	4.4					2259	3.9
11	0349	-0.7	26	0411	0.0	11	0456	-0.6	26	0434	0.4	11	0021	4.6	26	0449	0.7
F	0956	4.9	SA	1031	4.5	M	1124	5.6	TU	1101	4.6	TH	0615	0.2	F	1128	4.6
	1558	-0.2		1625	0.5		1727	-0.1		1657	0.8		1251	5.3		1745	0.9
	2211	5.5		2234	4.7		2344	5.1		2250	4.2		1911	0.4		2354	3.8
12	0434	-0.7	27	0445	0.2	12	0545	-0.3	27	0456	0.6	12	0119	4.3	27	0527	0.9
SA	1053	5.1	SU	1111	4.4	TU	1220	5.5	W	1133	4.5	F	0724	0.6	SA	1221	4.6
	1648	-0.1		1657	0.7		1828	0.2		1728	1.0		1348	5.1		1852	1.0
	2307	5.3		2312	4.4					2333	4.0		2021	0.6			
13	0520	-0.5	28	0517	0.4	13	0039	4.8	28	0519	0.8	13	0220	4.1	28	0051	3.8
SU	1146	5.2	M	1149	4.4	W	0644	0.0	TH	1210	4.5	SA	0835	0.8	SU	0626	1.1
	1744	0.1		1730	1.0		1314	5.4		1810	1.2		1448	4.9		1322	4.6
				2346	4.2		1937	0.4					2126	0.6		2027	1.0
14	0002	5.1	29	0544	0.6	14	0137	4.4	29	0015	3.9	14	0322	4.0	29	0201	3.8
M	0610	-0.3	TU	1229	4.4	TH	0750	0.3	F	0556	0.9	SU	0939	0.8	M	0827	1.1
	1242	5.2		1813	1.2		1412	5.2		1255	4.5		1548	4.7		1428	4.6
	1849	0.3					2046	0.5		1943	1.3		2221	0.5		2135	0.7
15	0058	4.8	30	0018	4.0	15	0238	4.2	30	0110	3.7	15	0425	4.1	30	0315	4.0
TU	0710	-0.1	W	0610	0.8	F	0859	0.5	SA	0652	1.1	M	1035	0.7	TU	0946	0.8
	1337	5.2		1306	4.4		1512	5.1		1351	4.6		1649	4.8		1542	4.8
	2000	0.4		1922	1.3		2149	0.5		2106	1.1		2311	0.4		2230	0.3
			31	0057	3.8				31	0215	3.7						
			TH	0653	0.9				SU	0852	1.1						
				1345	4.4					1458	4.7						
				2037	1.3					2206	0.8						

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.
HEIGHTS ARE RECKONED FROM THE DATUM OF SOUNDINGS ON CHARTS OF THE LOCALITY WHICH IS MEAN LOW WATER.

Table 13-2.—Tidal Differences and Constants

No.	PLACE	POSITION		DIFFERENCES				RANGES		Mean Tide Level
		Lat.	Long.	Time		Height		Mean	Spring	
				High water	Low water	High water	Low water			
		° ′	° ′	h. m.	h. m.	feet	feet	feet	feet	feet
	NEW YORK and NEW JERSEY **New York Harbor** *Time meridian, 75°W.*									
1493	Coney Island	40 34	73 59	-0 03	-0 19	+0.1	0.0	4.7	5.7	2.3
1495	Norton Point, Gravesend Bay	40 35	74 00	-0 03	+0 01	+0.1	0.0	4.7	5.7	2.3
1497	Fort Wadsworth, The Narrows	40 36	74 03	+0 02	+0 12	-0.3	0.0	4.3	5.2	2.1
1499	Fort Hamilton, The Narrows	40 37	74 02	+0 03	+0 06	+0.1	0.0	4.7	5.7	2.3
				on NEW YORK, p.56						
1501	Bay Ridge	40 38	74 02	-0 24	-0 24	+0.1	0.0	4.6	5.6	2.3
1503	St. George, Staten Island	40 39	74 04	-0 21	-0 18	0.0	0.0	4.5	5.4	2.2
1505	Bayonne, New Jersey	40 41	74 06	-0 19	-0 08	0.0	0.0	4.5	5.4	2.2
1507	Gowanus Bay	40 40	74 01	-0 19	-0 15	-0.1	0.0	4.4	5.3	2.2
1509	Governors Island	40 42	74 01	-0 11	-0 06	-0.1	0.0	4.4	5.3	2.2
1511	NEW YORK (The Battery)	40 42	74 01	Daily predictions				4.5	5.4	2.2
	Hudson River‡									
1513	Jersey City, Pa. RR. Ferry, N. J.	40 43	74 02	+0 07	+0 07	-0.1	0.0	4.4	5.3	2.2
1515	New York, Desbrosses Street	40 43	74 01	+0 10	+0 10	-0.1	0.0	4.4	5.3	2.2
1517	New York, Chelsea Docks	40 45	74 01	+0 17	+0 18	-0.2	0.0	4.3	5.2	2.1
1519	Hoboken, Castle Point, N. J.	40 45	74 01	+0 17	+0 16	-0.2	0.0	4.3	5.2	2.1
1521	Weehawken, Days Point, N. J.	40 46	74 01	+0 24	+0 23	-0.3	0.0	4.2	5.0	2.1
1523	New York, Union Stock Yards	40 47	74 00	+0 27	+0 26	-0.3	0.0	4.2	5.0	2.1
1525	New York, 130th Street	40 49	73 58	+0 37	+0 36	-0.5	0.0	4.0	4.8	2.0
1527	George Washington Bridge	40 51	73 57	+0 46	+0 43	-0.6	0.0	3.9	4.6	1.9
1529	Spuyten Duyvil, West of RR. bridge	40 53	73 56	+0 58	+0 53	-0.7	0.0	3.8	4.5	1.9
1531	Yonkers	40 56	73 54	+1 09	+1 10	-0.8	0.0	3.7	4.4	1.8
1533	Dobbs Ferry	41 01	73 53	+1 29	+1 40	-1.1	0.0	3.4	4.0	1.7
1535	Tarrytown	41 05	73 52	+1 45	+1 54	-1.3	0.0	3.2	3.7	1.6
1537	Ossining	41 10	73 52	+1 53	+2 14	-1.4	0.0	3.1	3.6	1.5
1539	Haverstraw	41 12	73 58	+1 59	+2 25	-1.6	0.0	2.9	3.4	1.4
1541	Peekskill	41 17	73 56	+2 24	+3 00	-1.3	+0.3	2.9	3.4	1.7
1543	West Point	41 24	73 57	+3 16	+3 37	-1.5	+0.3	2.7	3.1	1.6
1545	Newburgh	41 30	74 00	+3 42	+4 00	-1.5	+0.2	2.8	3.2	1.6
1547	New Hamburg	41 35	73 57	+4 00	+4 25	-1.5	+0.1	2.9	3.3	1.5
1549	Poughkeepsie	41 42	73 57	+4 30	+4 43	-1.3	+0.1	3.1	3.5	1.6
1551	Hyde Park	41 47	73 57	+4 56	+5 09	-1.3	0.0	3.2	3.6	1.6
1553	Kingston Point	41 56	73 58	+5 16	+5 31	-0.9	-0.1	3.7	4.2	1.7
1555	Tivoli	42 04	73 56	+5 46	+6 01	-0.8	-0.2	3.9	4.4	1.7
1557	Catskill	42 13	73 51	+6 37	+6 55	-0.7	-0.3	4.1	4.6	1.7
1559	Hudson	42 15	73 48	+6 54	+7 09	-0.9	-0.4	4.0	4.4	1.6
				on ALBANY, p.60						
1561	Coxsackie	42 21	73 48	-1 01	-1 38	-0.5	+0.2	3.9	4.3	2.1
1563	New Baltimore	42 27	73 47	-0 34	-0 56	-0.1	+0.4	4.1	4.5	2.4
1565	Castleton-on-Hudson	42 32	73 46	-0 17	-0 29	-0.2	+0.1	4.3	4.7	2.2
1567	ALBANY	42 39	73 45	Daily predictions				4.6	5.0	2.5
1569	Troy	42 44	73 42	+0 08	+0 10	+0.1	0.0	4.7	5.1	2.3
	The Kills and Newark Bay			on NEW YORK, p.56						
	Kill Van Kull									
1571	Constable Hook	40 39	74 05	-0 34	-0 21	0.0	0.0	4.5	5.4	2.2
1573	New Brighton	40 39	74 05	-0 12	-0 18	0.0	0.0	4.5	5.4	2.2
1575	Port Richmond	40 38	74 08	-0 03	+0 05	0.0	0.0	4.5	5.4	2.2
1577	Bergen Point	40 39	74 08	+0 05	+0 03	+0.1	0.0	4.6	5.5	2.3

‡Values for the Hudson River above the George Washington Bridge are based upon averages for the six months May to October, when the fresh-water discharge is a minimum.

Depending on local conditions, the height of tide at a subordinate station may be found in several ways. If a height difference is given for height of high water, it is necessary only to apply this difference in accordance with its sign. If a ratio of ranges is given, height of the tide at the subordinate station can be obtained by multiplying this ratio by the height of both high and low tides at the reference station.

Although the ratio of ranges method usually is slightly more accurate, it seldom is used when height differences are listed. Where results of height differences would not be satisfactory, they are not given. One or two ratios of ranges are given instead. In a few places the two systems are combined into a ratio, plus or minus a correction.

Height of the tide at a specific time can be found by using table 3 of the Tide Tables (table 13-3). Explicit instructions on how to use the table are included with it.

PREDICTING HEIGHT OF TIDE

Now, let's see how Tide Tables are used to predict the height of tide at a specific spot for a particular time. Let's select a subordinate station to make a real problem. Suppose you're proceeding up the Hudson River, with orders to anchor near the George Washington Bridge. You expect to make the anchorage at 1100 on 5 September, and you want to know the height of the tide there at that time and date.

The George Washington Bridge is listed in table 2, Atlantic tide tables, as a subordinate station whose reference station is New York. Number 1527 in the extreme left column is the station number found by looking up George Washington Bridge in the index to table 2. Table 13-2 shows a specimen page. It lists constants, good on any date. You note that your time meridian is 75°W; therefore, the times listed are zone time of zone plus 5. (All times used in the tables are standard times and must be adjusted if daylight saving time is used.)

Four columns of differences are shown in the table: high water time differences, low water time difference, high water height difference, and low water height difference. Note that the time of high water for the George Washington Bridge is plus 0h 46m. This explanation means that high tides occur 46 minutes later at the bridge than they do at New York, the reference station. Similarly, low water occurs 43 minutes later at the bridge than tides at New York.

Under high water height difference you see the figure minus 0.6, meaning that the height of high water at the George Washington Bridge is 0.6 foot less than the height of high water at New York. In like manner, the low water height is found to be the same as the height at the reference station.

You now have all the data needed to apply to the information given in table 1 (table 13-1). In that table, run down the column to the date concerned (5 September). You note the following times and heights of high and low waters:

SEPTEMBER

DAY	TIME H.M.	HT. FT.
5	0127	-0.6
F	0730	5.5
	1348	-0.6
	1949	5.9

Applying the tidal difference for the George Washington Bridge (+46m), you find that high tide occurs at 0816 (0730 + 46). Low tide occurs at 1431 (1348 + 43), 43 minutes later than at the Battery.

You want to know the height of the tide at 1100, a time somewhere between the times of high and low water. Inasmuch as 1100 is later than time of high water, you know that the tide is falling at that time. By subtracting 0816 from 1431, you find that it takes 6h 15m for the tide to go all the way out at the bridge. Subtracting 0816 (time of high water) from 1100, you learn that the time you are concerned with is 2h 44m past high water. Note that the time you are interested in (1100) occurs 3h 31m before low water. Always select the high or low tide that gives you the smallest time difference. In this

Table 13-3.—Heights of Tide at Any Time

Duration of rise or fall, see footnote	Time from the nearest high water or low water														
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
4 00	0 08	0 16	0 24	0 32	0 40	0 48	0 56	1 04	1 12	1 20	1 28	1 36	1 44	1 52	2 00
4 20	0 09	0 17	0 26	0 35	0 43	0 52	1 01	1 09	1 18	1 27	1 35	1 44	1 53	2 01	2 10
4 40	0 09	0 19	0 28	0 37	0 47	0 56	1 05	1 15	1 24	1 33	1 43	1 52	2 01	2 11	2 20
5 00	0 10	0 20	0 30	0 40	0 50	1 00	1 10	1 20	1 30	1 40	1 50	2 00	2 10	2 20	2 30
5 20	0 11	0 21	0 32	0 43	0 53	1 04	1 15	1 25	1 36	1 47	1 57	2 08	2 19	2 29	2 40
5 40	0 11	0 23	0 34	0 45	0 57	1 08	1 19	1 31	1 42	1 53	2 05	2 16	2 27	2 39	2 50
6 00	0 12	0 24	0 36	0 48	1 00	1 12	1 24	1 36	1 48	2 00	2 12	2 24	2 36	2 48	3 00
6 20	0 13	0 25	0 38	0 51	1 03	1 16	1 29	1 41	1 54	2 07	2 19	2 32	2 45	2 57	3 10
6 40	0 13	0 27	0 40	0 53	1 07	1 20	1 33	1 47	2 00	2 13	2 27	2 40	2 53	3 07	3 20
7 00	0 14	0 28	0 42	0 56	1 10	1 24	1 38	1 52	2 06	2 20	2 34	2 48	3 02	3 16	3 30
7 20	0 15	0 29	0 44	0 59	1 13	1 28	1 43	1 57	2 12	2 27	2 41	2 56	3 11	3 25	3 40
7 40	0 15	0 31	0 46	1 01	1 17	1 32	1 47	2 03	2 18	2 33	2 49	3 04	3 19	3 35	3 50
8 00	0 16	0 32	0 48	1 04	1 20	1 36	1 52	2 08	2 24	2 40	2 56	3 12	3 28	3 44	4 00
8 20	0 17	0 33	0 50	1 07	1 23	1 40	1 57	2 13	2 30	2 47	3 03	3 20	3 37	3 53	4 10
8 40	0 17	0 35	0 52	1 09	1 27	1 44	2 01	2 19	2 36	2 53	3 11	3 28	3 45	4 03	4 20
9 00	0 18	0 36	0 54	1 12	1 30	1 48	2 06	2 24	2 42	3 00	3 18	3 36	3 54	4 12	4 30
9 20	0 19	0 37	0 56	1 15	1 33	1 52	2 11	2 29	2 48	3 07	3 25	3 44	4 03	4 21	4 40
9 40	0 19	0 39	0 58	1 17	1 37	1 56	2 15	2 35	2 54	3 13	3 33	3 52	4 11	4 31	4 50
10 00	0 20	0 40	1 00	1 20	1 40	2 00	2 20	2 40	3 00	3 20	3 40	4 00	4 20	4 40	5 00
10 20	0 21	0 41	1 02	1 23	1 43	2 04	2 25	2 45	3 06	3 27	3 47	4 08	4 29	4 49	5 10
10 40	0 21	0 43	1 04	1 25	1 47	2 08	2 29	2 51	3 12	3 33	3 55	4 16	4 37	4 59	5 20

Range of tide, see footnote	Correction to height														
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5
1.5	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8
2.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
2.5	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.2
3.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5
3.5	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.4	1.6	1.8
4.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.2	1.4	1.6	1.8	2.0
4.5	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.6	1.8	2.0	2.2
5.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.7	2.0	2.2	2.5
5.5	0.0	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.4	1.6	1.9	2.2	2.5	2.8
6.0	0.0	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.2	1.5	1.8	2.1	2.4	2.7	3.0
6.5	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.3	1.6	1.9	2.2	2.6	2.9	3.2
7.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1	2.4	2.8	3.1	3.5
7.5	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.5	1.9	2.2	2.6	3.0	3.4	3.8
8.0	0.0	0.1	0.2	0.3	0.5	0.8	1.0	1.3	1.6	2.0	2.4	2.8	3.2	3.6	4.0
8.5	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.1	2.5	2.9	3.4	3.8	4.2
9.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5	1.9	2.2	2.7	3.1	3.6	4.0	4.5
9.5	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6	2.0	2.4	2.8	3.3	3.8	4.3	4.8
10.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.7	2.1	2.5	3.0	3.5	4.0	4.5	5.0
10.5	0.0	0.1	0.3	0.5	0.7	1.0	1.3	1.7	2.2	2.6	3.1	3.6	4.2	4.7	5.2
11.0	0.0	0.1	0.3	0.5	0.7	1.1	1.4	1.8	2.3	2.8	3.3	3.8	4.4	4.9	5.5
11.5	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.4	2.9	3.4	4.0	4.6	5.1	5.8
12.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.5	3.0	3.6	4.1	4.8	5.4	6.0
12.5	0.0	0.1	0.3	0.5	0.8	1.2	1.6	2.1	2.6	3.1	3.7	4.3	5.0	5.6	6.2
13.0	0.0	0.1	0.3	0.6	0.9	1.2	1.7	2.2	2.7	3.2	3.9	4.5	5.1	5.8	6.5
13.5	0.0	0.1	0.3	0.6	0.9	1.3	1.7	2.2	2.8	3.4	4.0	4.7	5.3	6.0	6.8
14.0	0.0	0.2	0.3	0.6	0.9	1.3	1.8	2.3	2.9	3.5	4.2	4.8	5.5	6.3	7.0
14.5	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.4	3.0	3.6	4.3	5.0	5.7	6.5	7.2
15.0	0.0	0.2	0.4	0.6	1.0	1.4	1.9	2.5	3.1	3.8	4.4	5.2	5.9	6.7	7.5
15.5	0.0	0.2	0.4	0.7	1.0	1.5	2.0	2.6	3.2	3.9	4.6	5.4	6.1	6.9	7.8
16.0	0.0	0.2	0.4	0.7	1.1	1.5	2.1	2.6	3.3	4.0	4.7	5.5	6.3	7.2	8.0
16.5	0.0	0.2	0.4	0.7	1.1	1.6	2.1	2.7	3.4	4.1	4.9	5.7	6.5	7.4	8.2
17.0	0.0	0.2	0.4	0.7	1.1	1.6	2.2	2.8	3.5	4.2	5.0	5.9	6.7	7.6	8.5
17.5	0.0	0.2	0.4	0.8	1.2	1.7	2.2	2.9	3.6	4.4	5.2	6.0	6.9	7.8	8.8
18.0	0.0	0.2	0.4	0.8	1.2	1.7	2.3	3.0	3.7	4.5	5.3	6.2	7.1	8.1	9.0
18.5	0.1	0.2	0.5	0.8	1.2	1.8	2.4	3.1	3.8	4.6	5.5	6.4	7.3	8.3	9.2
19.0	0.1	0.2	0.5	0.8	1.3	1.8	2.4	3.1	3.9	4.8	5.6	6.6	7.5	8.5	9.5
19.5	0.1	0.2	0.5	0.8	1.3	1.9	2.5	3.2	4.0	4.9	5.8	6.7	7.7	8.7	9.8
20.0	0.1	0.2	0.5	0.9	1.3	1.9	2.6	3.3	4.1	5.0	5.9	6.9	7.9	9.0	10.0

Obtain from the predictions the high water and low water, one of which is before and the other after the time for which the height is required. The difference between the times of occurrence of these tides is the duration of rise or fall, and the difference between their heights is the range of tide for the above table. Find the difference between the nearest high or low water and the time for which the height is required.

Enter the table with the duration of rise or fall, printed in heavy-faced type, which most nearly agrees with the actual value, and on that horizontal line find the time from the nearest high or low water which agrees most nearly with the corresponding actual difference. The correction sought is in the column directly below, on the line with the range of tide.

When the nearest tide is high water, subtract the correction.

When the nearest tide is low water, add the correction.

problem, you would choose the high tide, so that the time difference is 2h 44m.

Table 13-1 tells you that the height of high water at the reference station is 5.5. From table 13-2 you learned that the height of high water at the George Washington Bridge is 0.6 foot less than it is at the reference station. Therefore, the height of water at the bridge is 4.9 feet.

The height of low water at the bridge is the same as the low water at the reference station, which is minus 0.6 foot. Subtract -0.6 from 4.9 feet (height of high water at the bridge), and you find the range of the tide at the bridge is 5.5 feet.

Turning to table 3 (table 13-3), you can find the height of the tide at any time. You know that the duration of fall in this instance is 6h 15m and that the time you are concerned with is 2h 44m past high water. Table 3 should then be entered with 6h 20m (closest listed time to 6h 15m). Run across to 2h 45m in the thirteenth column. (Time 2h 45m is the closest time to 2h 44m.)

Proceed down this column to the Correction Height part of the table. You know that the range at the bridge is 5.5 feet, and the closest value to this figure listed in the Range of Tide column (at the left of the table) is 5.5 feet. Where the 5.5 range of tide line intersects the time from nearest high water column, you read the correction to height, which is 2.2 feet. The tide will have fallen this amount below high tide by 1100. By subtracting 2.2 feet from the height of high water at the bridge (5.5 feet), you learn that the height of the tide at 1100 will be 3.3 feet. (remember that all times listed are standard times and New York is on daylight saving time during September.)

TIDAL CURRENTS

You already have seen that tide is the vertical rise and fall of the ocean water level caused by the attraction of the Sun and Moon. A tidal current is periodic alternating horizontal response of the water to the tidal forces which causes the rise and fall of the tide. Tidal currents are so called to distinguish them from ocean or river currents.

The horizontal motions of water, which reverses its direction of flow during a tidal cycle, are called flood current and ebb current. The flood current sets toward and the ebb current away from the coast, or the flood and ebb currents set parallel to the coast in opposite directions. At each reversal of the current direction, there is an instant or short period of no horizontal motion called slack water.

At first glance, you might be inclined to presume that the time of a tidal current's change of direction should coincide with the time of changing tide. To the contrary, the change of direction of the current always lags the turning of the tide by an interval that varies according to the physical characteristics of the land around the body of tidewater. For instance, along a relatively straight coast with only shallow indentations, usually there is little difference between the time of high or low tide and the time of slack water. But where a large bay connects with the ocean through a narrow channel, the tide and the current may be out of phase by as much as 3 hours. In such a situation, the current in the channel may be running at its greatest velocity when it is high or low water outside.

SET AND DRIFT

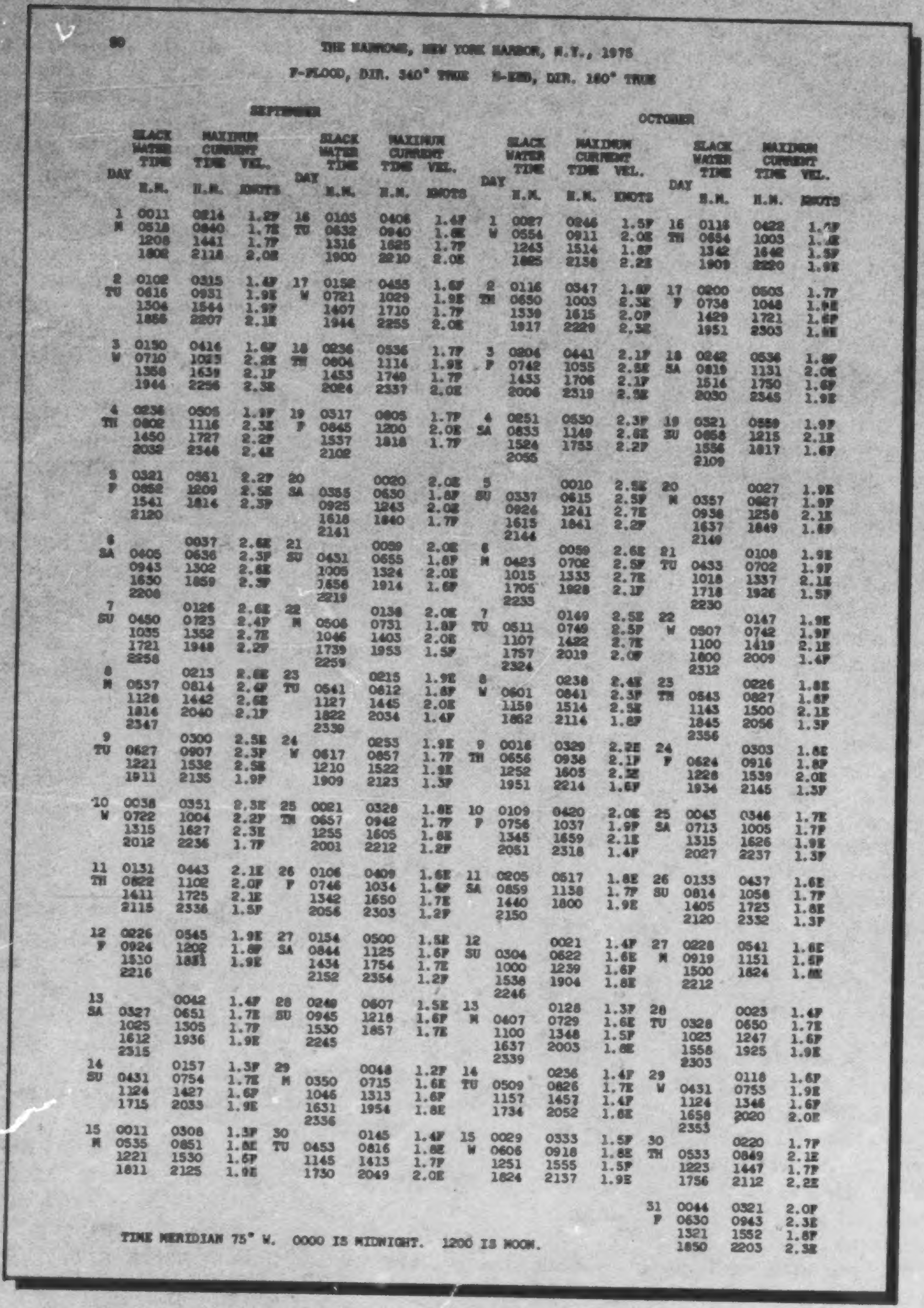
The navigator of a ship operating in tidewater must know the direction (called set) and velocity (called drift) of any tidal current his ship may encounter. This information is obtained from tidal current tables.

CURRENT TABLES

Tidal Current Tables is published annually by the National Ocean Survey. This publication is divided into predictions for reference stations (table 13-4) and current differences and other constants for subordinate stations (table 13-5). Table 13-4 lists predicted times of slack water and predicted times and velocities of maximum flood and ebb at the reference stations for each day of the year.

Table 13-5 includes the latitude and longitude of each subordinate station, time differences for slack water and maximum current, velocity ratios for maximum flood and ebb, and direction and average velocity for maximum flood and ebb currents.

Table 13-4.—Predictions for Reference Station



THE NARROWS, NEW YORK HARBOR, N.Y., 1975

F-FLOOD, DIR. 340° TRUE   E-EBB, DIR. 160° TRUE

SEPTEMBER								OCTOBER							
DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS	DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS	DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS	DAY	SLACK WATER TIME H.M.	MAXIMUM CURRENT TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
1 M	0011 0518 1208 1802	0214 0840 1441 2118	1.2F 1.7E 1.7F 2.0E	16 TU	0103 0632 1316 1900	0406 0940 1625 2210	1.4F 1.8E 1.7F 2.0E	1 W	0027 0554 1243 1825	0246 0911 1514 2138	1.5F 2.0E 1.8F 2.2E	16 TH	0118 0654 1342 1909	0422 1003 1642 2220	[illegible] [illegible] 1.5F 1.9E
2 TU	0102 0616 1304 1856	0315 0931 1544 2207	1.4F 1.9E 1.9F 2.1E	17 W	0152 0721 1407 1944	0455 1029 1710 2255	1.6F 1.9E 1.7F 2.0E	2 TH	0116 0650 1339 1917	0347 1003 1615 2229	1.8F 2.3E 2.0F 2.3E	17 F	0200 0738 1429 1951	0505 1048 1721 2303	1.7F 1.9E 1.6F 1.8E
3 W	0150 0710 1358 1944	0414 1023 1639 2256	1.6F 2.2E 2.1F 2.3E	18 TH	0236 0804 1453 2024	0536 1114 1740 2337	1.7F 1.9E 1.7F 2.0E	3 F	0204 0742 1433 2006	0441 1055 1706 2319	2.1F 2.5E 2.1F 2.5E	18 SA	0242 0819 1516 2030	0536 1131 1750 2345	1.8F 2.0E 1.6F 1.9E
4 TH	0236 0802 1450 2032	0505 1116 1727 2346	1.9F 2.3E 2.2F 2.4E	19 F	0317 0845 1537 2102	0605 1200 1818	1.7F 2.0E 1.7F	4 SA	0251 0833 1524 2056	0530 1149 1755	2.3F 2.6E 2.2F	19 SU	0321 0858 1556 2109	0559 1215 1817	1.9F 2.1E 1.6F
5 F	0321 0852 1541 2120	0551 1209 1814	2.2F 2.5E 2.3F	20 SA	0355 0925 1618 2141	0020 0630 1243 1840	2.0E 1.8F 2.0E 1.7F	5 SU	0337 0926 1615 2144	0010 0615 1241 1841	2.5E 2.5F 2.7E 2.2F	20 M	0357 0938 1637 2149	0027 0627 1258 1849	1.9E 1.9F 2.1E 1.8F
6 SA	0405 0943 1630 2208	0037 0636 1302 1859	2.6E 2.3F 2.6E 2.3F	21 SU	0431 1005 1656 2219	0059 0655 1324 1914	2.0E 1.8F 2.0E 1.6F	6 M	0423 1015 1705 2233	0059 0702 1333 1928	2.6E 2.5F 2.7E 2.1F	21 TU	0433 1018 1718 2230	0108 0702 1337 1926	1.9E 1.9F 2.1E 1.5F
7 SU	0450 1035 1721 2258	0126 0723 1352 1948	2.6E 2.4F 2.7E 2.2F	22 M	0506 1046 1739 2259	0138 0731 1403 1953	2.0E 1.8F 2.0E 1.5F	7 TU	0511 1107 1757 2324	0149 0749 1422 2019	2.5E 2.5F 2.7E 2.0F	22 W	0507 1100 1800 2312	0147 0742 1419 2009	1.9E 1.9F 2.1E 1.4F
8 M	0537 1128 1814 2347	0213 0814 1442 2040	2.6E 2.4F 2.6E 2.1F	23 TU	0541 1127 1822 2339	0215 0812 1445 2034	1.9E 1.8F 2.0E 1.4F	8 W	0601 1159 1852	0238 0841 1514 2114	2.4E 2.3F 2.5E 1.8F	23 TH	0543 1143 1845 2356	0226 0827 1500 2056	1.8E 1.8F 2.1E 1.3F
9 TU	0627 1221 1911	0300 0907 1532 2135	2.5E 2.3F 2.5E 1.9F	24 W	0617 1210 1909	0253 0857 1522 2123	1.9E 1.7F 1.9E 1.3F	9 TH	0016 0656 1252 1951	0329 0938 1605 2214	2.2E 2.1F 2.2E 1.6F	24 F	0624 1228 1934	0303 0916 1539 2145	1.8E 1.8F 2.0E 1.3F
10 W	0038 0722 1315 2012	0351 1004 1627 2236	2.3E 2.2F 2.3E 1.7F	25 TH	0021 0657 1255 2001	0328 0942 1605 2212	1.8E 1.7F 1.8E 1.2F	10 F	0109 0756 1345 2051	0420 1037 1659 2318	2.0E 1.9F 2.1E 1.4F	25 SA	0043 0713 1315 2027	0346 1005 1626 2237	1.7E 1.7F 1.9E 1.3F
11 TH	0131 0822 1411 2115	0443 1102 1725 2336	2.1E 2.0F 2.1E 1.5F	26 F	0106 0746 1342 2056	0409 1034 1650 2303	1.6E 1.6F 1.7E 1.2F	11 SA	0205 0859 1440 2150	0517 1138 1800	1.8E 1.7F 1.9E	26 SU	0133 0814 1405 2120	0437 1058 1723 2332	1.6E 1.7F 1.8E 1.3F
12 F	0226 0924 1530 2216	0545 1202 1851	1.9E 1.8F 1.9E	27 SA	0154 0844 1434 2152	0500 1125 1754 2354	1.5E 1.6F 1.7E 1.2F	12 SU	0304 1000 1538 2246	0021 0622 1239 1904	1.4F 1.6E 1.6F 1.8E	27 M	0228 0919 1500 2212	0541 1151 1824	1.6E 1.5F [illegible]
13 SA	0327 1025 1612 2315	0042 0651 1305 1936	1.4F 1.7E 1.7F 1.9E	28 SU	0249 0945 1530 2245	0607 1218 1857	1.5E 1.6F 1.7E	13 M	0407 1100 1637 2339	0128 0729 1348 2003	1.3F 1.6E 1.5F 1.8E	28 TU	0328 1023 1558 2303	0023 0650 1247 1925	1.4F 1.7E 1.6F 1.9E
14 SU	0431 1124 1715	0157 0754 1427 2033	1.3F 1.7E 1.6F 1.9E	29 M	0350 1046 1631 2336	0048 0715 1313 1954	1.2F 1.6E 1.6F 1.8E	14 TU	0509 1157 1734	0236 0826 1457 2052	1.4F 1.7E 1.4F 1.8E	29 W	0431 1124 1658 2353	0118 0753 1346 2020	1.6F 1.9E 1.6F 2.0E
15 M	0011 0535 1221 1811	0308 0851 1530 2125	1.3F 1.8E 1.6F 1.9E	30 TU	0453 1145 1730	0145 0816 1413 2049	1.4F 1.8E 1.7F 2.0E	15 W	0029 0606 1251 1824	0333 0918 1555 2137	1.5F 1.8E 1.5F 1.9E	30 TH	0533 1223 1756	0220 0849 1447 2112	1.7F 2.1E 1.7F 2.2E
												31 F	0044 0630 1321 1850	0321 0943 1552 2203	2.0F 2.3E 1.8F 2.3E

TIME MERIDIAN 75° W. 0000 IS MIDNIGHT. 1200 IS NOON.

Table 13-5.—Current Differences and Constants

No.	PLACE	POSITION		TIME DIFFERENCES		VELOCITY RATIOS		MAXIMUM CURRENTS			
								Flood		Ebb	
		Lat.	Long.	Slack water	Maximum current	Maximum flood	Maximum ebb	Direction (true)	Average velocity	Direction (true)	Average velocity
		° ′	° ′	h. m.	h. m.			deg.	knots	deg.	knots
	LONG ISLAND, South Coast—Continued *Time meridian, 75°W.*	N.	W.	on THE NARROWS, p.46							
2245	Ponquogue bridge, Shinnecock Bay	40 51	72 30	+0 40	+0 35	0.5	0.3	250	0.8	090	0.6
2250	Shinnecock Inlet	40 51	72 29	-0 20	-0 40	1.5	1.2	350	2.5	170	2.3
2255	Fire I. inlet, 0.5 mi. S. of Oak Beach	40 38	73 18	+0 15	0 00	1.4	1.2	080	2.4	245	2.4
2260	Jones Inlet	40 35	73 34	-1 00	-0 55	1.8	1.3	035	3.1	215	2.6
2265	Long Beach, inside, between bridges	40 36	73 40	-0 10	+0 10	0.3	0.3	075	0.5	275	0.6
2270	East Rockaway Inlet	40 35	73 45	-1 25	-1 35	1.3	1.2	040	2.2	225	2.3
2275	Ambrose Light	40 27	73 49	See table 5.							
2280	Sandy Hook App. Lighted Horn Buoy 2A	40 27	73 55	See table 5.							
	JAMAICA BAY										
2285	Rockaway Inlet	40 34	73 56	-1 45	-2 15	1.1	1.3	065	1.8	245	2.7
2290	Barren Island, east of	40 35	73 53	-2 00	-2 25	0.7	0.9	005	1.2	190	1.7
2295	Canarsie (midchannel, off pier)	40 38	73 53	-1 35	-1 50	0.3	0.3	045	0.5	220	0.7
2300	Beach Channel (bridge)	40 35	73 49	-1 20	-1 20	1.1	1.0	060	1.9	225	2.0
2305	Grass Hassock Channel	40 37	73 47	-1 10	-1 00	0.6	0.5	060	1.0	230	1.0
	NEW YORK HARBOR ENTRANCE										
2310	Ambrose Channel entrance	40 30	73 58	-1 10	-1 05	1.0	1.2	310	1.7	110	2.3
2315	Ambrose Channel, SE. of West Bank Lt	40 32	74 01	(1)	-0 25	0.8	0.9	310	1.3	170	1.8
2320	Coney Island Lt., 1.6 miles SSW. of	40 33	74 01	-0 10	(2)	0.5	0.8	330	0.8	145	1.5
2325	Ambrose Channel, north end	40 34	74 02	+0 05	+0 15	0.8	0.9	330	1.3	175	1.9
2330	Coney Island, 0.2 mile west of	40 35	74 01	-0 55	-0 55	0.9	1.0	330	1.5	170	2.0
2335	Ft. Lafayette, channel east of	40 36	74 02	(3)	(3)	0.6	0.5	345	1.1	195	0.9
2340	THE NARROWS, midchannel	40 37	74 03	Daily predictions				340	1.7	160	2.0
	NEW YORK HARBOR, Upper Bay										
2345	Tompkinsville	40 38	74 04	-0 10	+0 20	0.9	1.0	005	1.6	170	2.0
2350	Bay Ridge Channel	40 39	74 02	-0 35	-0 45	0.6	0.6	040	1.0	220	1.1
2355	Red Hook Channel	40 40	74 01	-0 35	-0 35	0.6	0.4	355	1.0	170	0.7
2360	Robbins Reef Light, east of	40 39	74 03	+0 10	+0 20	0.8	0.8	015	1.3	205	1.6
2365	Red Hook, 1 mile west of	40 41	74 02	+0 45	+1 00	0.8	1.2	025	1.3	205	2.3
2370	Statue of Liberty, east of	40 42	74 02	+0 55	+1 00	0.8	1.0	030	1.4	205	1.9
	HUDSON RIVER, Midchannel[4]										
2375	The Battery, northwest of	40 43	74 02	+1 30	+1 35	0.9	1.2	015	1.5	195	2.3
2380	Desbrosses Street	40 43	74 01	+1 35	+1 40	0.9	1.2	010	1.5	----	2.3
2385	Chelsea Docks	40 45	74 01	+1 30	+1 40	1.0	1.0	020	1.7	185	2.0
2390	Forty-second Street	40 46	74 00	+1 35	+1 45	1.0	1.2	030	1.7	----	2.3
2395	Ninety-sixth Street	40 48	73 59	+1 40	+1 50	1.0	1.2	030	1.7	----	2.3
2400	Grants Tomb, 123d Street	40 49	73 58	+1 45	+1 55	0.9	1.2	025	1.6	----	2.3
2405	George Washington Bridge	40 51	73 57	+1 45	+2 00	0.9	1.1	020	1.6	200	2.2
2410	Spuyten Duyvil	40 53	73 56	+2 00	+2 10	0.9	1.1	020	1.6	----	2.1
2415	Riverdale	40 54	73 55	+2 05	+2 20	0.8	1.0	015	1.4	200	2.0
2420	Dobbs Ferry	41 01	73 53	+2 25	+2 40	0.8	0.9	010	1.3	----	1.7
2425	Terrytown	41 05	73 53	+2 40	+2 55	0.6	0.8	000	1.1	----	1.5
2430	Ossining	41 10	73 54	+2 55	+3 10	0.5	0.7	350	0.9	----	1.3
2435	Haverstraw	41 12	73 57	+3 05	+3 15	0.5	0.7	335	0.8	----	1.3
2440	Peekskill	41 17	73 57	+3 20	+3 35	0.5	0.6	000	0.8	----	1.2
2445	Bear Mountain Bridge	41 19	73 59	+3 25	+3 40	0.5	0.6	000	0.8	----	1.1
2450	Highland Falls	41 22	73 58	+3 35	+3 50	0.6	0.6	005	1.0	185	1.2
2455	West Point, off Duck Island	41 24	73 57	+3 40	+3 55	0.5	0.6	010	1.0	----	1.1

[1] Current is rotary, turning clockwise. Minimum current of 0.9 knot sets SW. about time of "Slack, flood begins" at The Narrows. Minimum current of 0.5 knot sets NE. about 1 hour before "Slack, ebb begins" at The Narrows.

[2] Maximum flood, -0h 50m; maximum ebb, +0h 55m.

[3] Flood begins, -2h 15m; maximum flood, -0h 05m; ebb begins, +0h 05m; maximum ebb, -1h 50m.

[4] The values for the Hudson River are for the summer months, when the fresh-water discharge is a minimum.

69.80

Time differences are applied to the times of slack and maximum current at the reference station in the same manner that time differences are applied when figuring tides. Application of the time difference to the tabulated time of flood and ebb current produces the time of the corresponding current at the subordinate station. Maximum velocity at the subordinate station is found by multiplying the maximum velocity at the reference station by the appropriate flood or ebb ratio.

Flood direction is the approximate true direction toward which the flood current flows. Ebb direction is usually close to the reciprocal of the flood direction. Average flood and ebb velocities are averages of all the flood and ebb currents.

Table 3 in the Tidal Current Tables (table 13-6) is similar to table 3 in the tide tables. It is used for finding the velocity of the current at any time.

PREDICTING SET AND DRIFT OF CURRENT

Now let's see if we can determine the set and drift of the current at the George Washington Bridge for the same time (1100) on the same day for which we predicted the height of the tide. First, notice near the top of the page in table 13-5 that the current reference station for the George Washington Bridge is the Narrows, instead of the Battery as it was for the tide. You see the time difference for slack water and the maximum current are plus 1h 45m and plus 2h 00m. These time differences mean that, when slack water or maximum current exists at the Narrows, the same conditions will exist 1h 45m and 2h 00m later, respectively, at the George Washington Bridge.

The flood velocity ratio is 0.9 and the ebb velocity ratio is 1.1. Before selecting the correct ratio, you must determine whether the current is flooding or ebbing at 1100.

Under the Maximum Currents columns, you find that the flood direction is 020° and that the ebb direction is the reciprocal, or 200°. The average flood velocity is 1.6 knots, and the average ebb velocity is 2.2 knots.

You now have all the values needed to find the conditions at the George Washington Bridge. These values are:

Time differences:	+1h 45m—slack water +2h 00m—max. current
Velocity ratios:	0.9—flood 1.1—ebb
Direction of current:	020°—flood 200°—ebb

Turning to table 13-4, the Narrows, you find the following data:

DAY	SLACK WATER TIME H.M.	TIME H.M.	MAXIMUM CURRENT VEL. KNOTS
5	0321	0551	2.2F
F	0852	1209	2.5E
	1541	1814	2.3F
	2120		

It is seen that the time of maximum current is 1209 and that the slack water occurs at 0852. You choose these values because they must straddle the desired time.

You want to know the set and drift of the current at the bridge at 1100. At the bridge the maximum current velocity occurs 2h 00m after the maximum velocity at the Narrows. Therefore, the maximum current velocity—and in this example it is an ebb velocity—occurs at 1409. By the same method, the slack water occurs at the bridge at 1037. Because the current is ebbing from 1037 to 1409, you have established an ebb current at 1100; hence, you will use the ebb ratio.

Multiplying the maximum ebb velocity at the Narrows (2.5 knots) by the ebb ratio for the bridge (1.1), you arrive at a value of 2.7 knots for the maximum ebb velocity at the bridge.

Now turn to table 3 of the Tidal Current Tables (table 13-6) and figure the velocity of the current at the bridge at 1100. You enter the table with the interval between slack and

Table 13-6.–Velocity of Current at Any Time

TABLE A

Interval between slack and desired time	Interval between slack and maximum current													
h. m.	h. m. 1 20	h. m. 1 40	h. m. 2 00	h. m. 2 20	h. m. 2 40	h. m. 3 00	h. m. 3 20	h. m. 3 40	h. m. 4 00	h. m. 4 20	h. m. 4 40	h. m. 5 00	h. m. 5 20	h. m. 5 40
	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.
0 20	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0 40	0.7	0.6	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
1 00	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3
1 20	1.0	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4
1 40	---	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4
2 00	---	---	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5
2 20	---	---	---	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6
2 40	---	---	---	---	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7
3 00	---	---	---	---	---	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.7
3 20	---	---	---	---	---	---	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8
3 40	---	---	---	---	---	---	---	1.0	1.0	1.0	0.9	0.9	0.9	0.9
4 00	---	---	---	---	---	---	---	---	1.0	1.0	1.0	1.0	0.9	0.9
4 20	---	---	---	---	---	---	---	---	---	1.0	1.0	1.0	1.0	0.9
4 40	---	---	---	---	---	---	---	---	---	---	1.0	1.0	1.0	1.0
5 00	---	---	---	---	---	---	---	---	---	---	---	1.0	1.0	1.0
5 20	---	---	---	---	---	---	---	---	---	---	---	---	1.0	1.0
5 40	---	---	---	---	---	---	---	---	---	---	---	---	---	1.0

TABLE B

Interval between slack and desired time	Interval between slack and maximum current													
h. m.	h. m. 1 20	h. m. 1 40	h. m. 2 00	h. m. 2 20	h. m. 2 40	h. m. 3 00	h. m. 3 20	h. m. 3 40	h. m. 4 00	h. m. 4 20	h. m. 4 40	h. m. 5 00	h. m. 5 20	h. m. 5 40
	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.	f.
0 20	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
0 40	0.8	0.7	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
1 00	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.4
1 20	1.0	1.0	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5
1 40	---	1.0	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6
2 00	---	---	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.6
2 20	---	---	---	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7
2 40	---	---	---	---	1.0	1.0	1.0	0.9	0.9	0.9	0.8	0.8	0.8	0.7
3 00	---	---	---	---	---	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8
3 20	---	---	---	---	---	---	1.0	1.0	1.0	1.0	0.9	0.9	0.9	0.8
3 40	---	---	---	---	---	---	---	1.0	1.0	1.0	1.0	0.9	0.9	0.9
4 00	---	---	---	---	---	---	---	---	1.0	1.0	1.0	1.0	0.9	0.9
4 20	---	---	---	---	---	---	---	---	---	1.0	1.0	1.0	1.0	0.9
4 40	---	---	---	---	---	---	---	---	---	---	1.0	1.0	1.0	1.0
5 00	---	---	---	---	---	---	---	---	---	---	---	1.0	1.0	1.0
5 20	---	---	---	---	---	---	---	---	---	---	---	---	1.0	1.0
5 40	---	---	---	---	---	---	---	---	---	---	---	---	---	1.0

Use Table A for all places except those listed below for Table B.

Use Table B for Cape Cod Canal, Hell Gate, Chesapeake and Delaware Canal and all stations in Table 2 which are referred to them.

1. From predictions find the time of slack water and the time and velocity of maximum current (flood or ebb), one of which is immediately before and the other after the time for which the velocity is desired.
2. Find the interval of time between the above slack and maximum current, and enter the top of Table A or B with the interval which most nearly agrees with this value.
3. Find the interval of time between the above slack and the time desired, and enter the side of Table A or B with the interval which most nearly agrees with this value.
4. Find, in the table, the factor corresponding to the above two intervals, and multiply the maximum velocity by this factor. The result will be the approximate velocity at the time desired.

maximum current (1037 - 1409 or 3h 32m) and the interval between slack and desired time (1037 - 1100 or 0h 23m). The value in the table closest to the former time is 3h 40m. The value closest to the latter time is 0h 20m. Where these two lines intersect in the table you find the correction value of 0.1. Multiply the velocity of the maximum ebb current (2.7 knots) by this factor and you get the velocity at 1100, which is 0.3 knots.

What is the direction, or set? You know that the current is ebbing at this time, and the ebb direction is 200°, which is the set.

In using both the tide and the current tables, you must bear in mind that frequently actual conditions vary considerably from predicted conditions in the tables. Changes in wind force and direction, or variations in atmospheric pressure, produce variations in the ocean water level, especially the high water height. For instance, a hurricane struck the New England coast in September 1938, piling up a tremendous wall of water in Narragansett Bay and increasing it to the point where, when it struck the city of Providence, it assumed the proportions of a huge storm wave. Generally speaking, the actual heights of both high- and low-water level are higher than the predicted heights with an onshore wind or a low barometer. With an off-shore wind or a high barometer, those heights usually are lower than predicted.

When working with the tidal current tables, remember that the actual times of slack or strength of current may sometimes differ from the predicted times by as much as ½ hours. On rare occasions the difference may be as much as 1 hour. A record of comparison between predicted and observed times of slack water, however, shows that more than 90% of slack water predictions are accurate to within ½ hour. Consequently, in order to be certain of getting the full advantage of a favorable current or slack water, the navigator may plan to reach an entrance or strait ½ hour before the predicted time of the desired condition of the current.

Winds, variations in stream discharges produced by heavy rain, and other weather factors frequently have an effect upon direction and velocity of current. When any of these phenomena occur, actual current conditions vary from those predicted. The ability to estimate the amount by which they vary can be acquired only through experience.

SUNRISE AND SUNSET

You probably know that practically the only time for obtaining observations of the heavenly bodies (with the exception of the Sun and Moon) is during morning and evening twilight, when both the stars and the horizons are visible. Morning twilight in middle latitudes normally begins nearly 30 minutes before sunrise. By approximately 15 minutes before sunrise, the stars usually fade to the point where observations no longer are possible. Observations in the evening usually are possible from between 15 and 30 minutes after sunset.

The foregoing times are only approximate, and they vary with change of latitude. Unusual conditions of visibility also cause them to vary somewhat. In any event, you can see that it is essential for the navigator to know the time when sunrise or sunset will occur. In port, when no observations are taken, the time of sunrise or sunset still is important in connection with making evening colors, lights, and the like.

SUNRISE AND SUNSET BY TIDE TABLES

Tide Tables contain tables for determining times of sunrise and sunset. These tables differ from those given in the Nautical Almanac in that times are given for every fifth day instead of every third day in the year.

You can see at once that, inasmuch as the times are given only for every fifth day, some interpolation is required for the days between. The same requirement is applicable to routine interpolation for latitude.

From the tide tables, let's try to find the time of sunrise and sunset at Hampton Roads on 23 June 1975. Latitude is 36°57′N longitude 76°20′W.

Table 13-7 shows you the appropriate page from the 1975 Tide Tables. Note that 23 June falls between tabulations for 20 June and 25 June, and that latitude 37°N falls between 36°N

Table 13-7.–Sunrise and Sunset from Tide Tables

Date	30° N.		32° N.		34° N.		36° N.		38° N.		40° N.	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Jan. 1	6 56	17 11	7 01	17 07	7 06	17 02	7 11	16 57	7 16	16 51	7 22	16 44
6	6 57	17 15	7 02	17 11	7 06	17 06	7 11	17 01	7 17	16 56	7 22	16 49
11	6 57	17 19	7 02	17 15	7 06	17 10	7 11	17 05	7 16	17 00	7 22	16 54
16	6 57	17 23	7 01	17 19	7 05	17 15	7 10	17 10	7 15	17 05	7 20	17 00
21	6 56	17 27	6 59	17 24	7 04	17 20	7 08	17 15	7 12	17 11	7 18	17 05
26	6 54	17 32	6 57	17 28	7 01	17 25	7 05	17 21	7 09	17 16	7 14	17 11
31	6 51	17 36	6 55	17 33	6 58	17 29	7 02	17 26	7 06	17 22	7 10	17 17
Feb. 5	6 48	17 40	6 51	17 37	6 54	17 34	6 58	17 31	7 01	17 27	7 05	17 23
10	6 45	17 44	6 47	17 42	6 50	17 39	6 53	17 36	6 56	17 33	7 00	17 29
15	6 41	17 48	6 43	17 46	6 45	17 44	6 48	17 41	6 50	17 39	6 54	17 35
20	6 36	17 52	6 38	17 50	6 40	17 48	6 42	17 46	6 44	17 44	6 47	17 41
25	6 31	17 56	6 32	17 55	6 34	17 53	6 36	17 51	6 38	17 49	6 41	17 47
Mar. 2	6 26	17 59	6 27	17 58	6 28	17 57	6 29	17 56	6 31	17 54	6 33	17 52
7	6 20	18 03	6 21	18 02	6 22	18 01	6 23	18 00	6 25	17 59	6 26	17 58
12	6 14	18 06	6 14	18 06	6 15	18 05	6 16	18 05	6 17	18 04	6 18	18 03
17	6 09	18 09	6 09	18 09	6 09	18 09	6 09	18 09	6 10	18 09	6 10	18 08
22	6 02	18 12	6 03	18 12	6 02	18 13	6 02	18 13	6 02	18 13	6 02	18 13
27	5 56	18 15	5 56	18 16	5 55	18 17	5 54	18 17	5 53	18 18	5 53	18 18
Apr. 1	5 50	18 18	5 49	18 20	5 48	18 21	5 47	18 22	5 46	18 23	5 45	18 24
6	5 44	18 21	5 43	18 23	5 41	18 24	5 40	18 26	5 38	18 27	5 37	18 29
11	5 39	18 24	5 36	18 26	5 35	18 28	5 33	18 30	5 32	18 32	5 30	18 34
16	5 33	18 27	5 31	18 30	5 29	18 32	5 26	18 34	5 24	18 37	5 22	18 39
21	5 28	18 31	5 26	18 33	5 23	18 36	5 20	18 39	5 17	18 41	5 15	18 44
26	5 23	18 34	5 19	18 37	5 17	18 40	5 13	18 43	5 10	18 46	5 08	18 49
May 1	5 18	18 37	5 14	18 40	5 11	18 43	5 08	18 47	5 04	18 51	5 01	18 54
6	5 14	18 40	5 10	18 44	5 06	18 47	5 03	18 51	4 59	18 55	4 55	18 59
11	5 10	18 43	5 06	18 47	5 02	18 51	4 58	18 55	4 54	19 00	4 49	19 04
16	5 06	18 47	5 02	18 51	4 58	18 55	4 54	18 59	4 49	19 04	4 45	19 09
21	5 04	18 50	4 59	18 54	4 55	18 59	4 50	19 03	4 45	19 08	4 40	19 13
26	5 01	18 52	4 57	18 57	4 52	19 02	4 47	19 07	4 42	19 12	4 37	19 18
31	5 00	18 56	4 55	19 00	4 50	19 05	4 45	19 11	4 40	19 16	4 34	19 21
June 5	4 59	18 58	4 54	19 03	4 49	19 08	4 43	19 14	4 38	19 19	4 32	19 25
10	4 58	19 00	4 53	19 05	4 48	19 11	4 43	19 17	4 37	19 22	4 31	19 28
15	4 58	19 02	4 53	19 07	4 48	19 13	4 43	19 18	4 37	19 24	4 30	19 30
20	4 59	19 04	4 54	19 09	4 49	19 14	4 43	19 20	4 37	19 26	4 31	19 32
25	5 00	19 05	4 55	19 10	4 50	19 15	4 44	19 21	4 38	19 26	4 32	19 33
30	5 02	19 05	4 57	19 10	4 52	19 15	4 46	19 21	4 40	19 27	4 34	19 33
July 5	5 04	19 05	4 59	19 10	4 54	19 15	4 49	19 20	4 43	19 26	4 36	19 32
10	5 06	19 04	5 02	19 09	4 57	19 14	4 51	19 19	4 46	19 25	4 39	19 31
15	5 09	19 03	5 04	19 07	5 00	19 12	4 54	19 17	4 49	19 22	4 43	19 28
20	5 11	19 01	5 07	19 05	5 03	19 10	4 58	19 14	4 53	19 19	4 47	19 25
25	5 14	18 58	5 10	19 02	5 06	19 06	5 02	19 11	4 57	19 16	4 51	19 21
30	5 17	18 55	5 14	18 59	5 10	19 03	5 05	19 07	5 01	19 11	4 56	19 17
Aug. 4	5 20	18 52	5 17	18 55	5 13	18 58	5 09	19 02	5 05	19 06	5 00	19 11
9	5 23	18 47	5 20	18 50	5 17	18 54	5 13	18 57	5 09	19 01	5 05	19 05
14	5 26	18 43	5 24	18 45	5 21	18 48	5 17	18 52	5 14	18 55	5 10	18 59
19	5 29	18 38	5 27	18 40	5 24	18 43	5 21	18 45	5 18	18 48	5 14	18 52
24	5 32	18 33	5 30	18 34	5 28	18 37	5 25	18 39	5 23	18 42	5 19	18 45
29	5 35	18 27	5 33	18 28	5 31	18 30	5 29	18 32	5 27	18 34	5 24	18 37
Sept. 3	5 38	18 21	5 36	18 22	5 35	18 24	5 33	18 25	5 31	18 28	5 29	18 30
8	5 40	18 15	5 39	18 16	5 38	18 17	5 37	18 18	5 35	18 19	5 34	18 22
13	5 43	18 09	5 42	18 10	5 42	18 11	5 41	18 11	5 40	18 12	5 38	18 13
18	5 46	18 03	5 46	18 03	5 45	18 04	5 44	18 04	5 43	18 05	5 43	18 05
23	5 48	17 56	5 48	17 56	5 48	17 57	5 48	17 57	5 48	17 57	5 48	17 57
28	5 51	17 50	5 51	17 50	5 52	17 49	5 52	17 49	5 53	17 49	5 53	17 49
Oct. 3	5 54	17 44	5 55	17 43	5 56	17 42	5 56	17 41	5 57	17 41	5 57	17 40
8	5 57	17 38	5 58	17 36	5 59	17 35	6 00	17 34	6 01	17 33	6 02	17 32
13	6 00	17 32	6 02	17 31	6 03	17 29	6 05	17 27	6 06	17 26	6 08	17 25
18	6 03	17 27	6 05	17 25	6 07	17 23	6 09	17 21	6 11	17 19	6 13	17 17
23	6 07	17 22	6 09	17 19	6 11	17 17	6 14	17 15	6 16	17 12	6 18	17 10
28	6 10	17 17	6 13	17 14	6 16	17 12	6 18	17 09	6 21	17 06	6 24	17 04
Nov. 2	6 14	17 13	6 17	17 10	6 20	17 07	6 23	17 04	6 26	17 00	6 29	16 57
7	6 18	17 09	6 22	17 06	6 25	17 02	6 28	16 59	6 32	16 55	6 35	16 52
12	6 22	17 06	6 26	17 02	6 29	16 59	6 33	16 55	6 37	16 51	6 41	16 47
17	6 26	17 03	6 30	16 59	6 34	16 56	6 38	16 51	6 43	16 47	6 47	16 43
22	6 30	17 01	6 35	16 57	6 39	16 53	6 43	16 49	6 48	16 44	6 52	16 39
27	6 34	17 00	6 39	16 56	6 44	16 52	6 48	16 47	6 53	16 42	6 58	16 37
Dec. 2	6 38	17 00	6 43	16 55	6 48	16 51	6 53	16 46	6 58	16 41	7 03	16 35
7	6 42	17 00	6 47	16 56	6 52	16 51	6 57	16 46	7 02	16 40	7 08	16 35
12	6 46	17 01	6 51	16 56	6 56	16 52	7 01	16 46	7 07	16 41	7 12	16 35
17	6 49	17 03	6 54	16 58	6 59	16 53	7 04	16 48	7 10	16 42	7 16	16 36
22	6 52	17 05	6 56	17 00	7 01	16 55	7 07	16 49	7 12	16 44	7 18	16 38
27	6 54	17 08	6 59	17 03	7 04	16 58	7 09	16 53	7 15	16 47	7 20	16 41
Jan. 1	6 56	17 11	7 01	17 07	7 06	17 01	7 11	16 56	7 16	16 50	7 22	16 44

Local mean time. To obtain standard time of rise or set, see Table 5.

69.82

and 38°N. Consequently, you make a two-way interpolation as follows:

1. Interpolate time of sunrise between 36° N and 38°N for 20 June 0440
2. Interpolate time of sunrise between 36° N and 38°N for 25 June 0441
3. Interpolate between 0440 and 0441 to get sunrise for 37°N on 23 June. 0441

(Actual interpolated value is 0440.5 but the usual practice is to round off fractions to the nearest whole number.)

Time of sunrise:	36°N	37°N	38°N
20 June------	0443	0440	0437
25 June------	0444	0441	0438
23 June------	----	0441	----

A correction for longitude can be found in table 5 of the Tide Tables. The difference of longitude between local and standard meridian is listed in one column, and the correction to local mean time is given alongside the Difference of Longitude column. For a longitude of 76°20 ′W, the correction is plus 5m. Therefore, the time of sunrise at Hampton Roads is 0446 zone time.

Compute the time of sunset at Hampton Roads in exactly the same way.

	36°N	37°N	38°N
20 June----	1920	1923	1926
25 June----	1921	1924	1926
23 June----	----	1924	----

Correction for longitude is plus 5m, so zone time of sunset for Hampton Roads on this day was 1929.

Time of sunrise and sunset for south latitude is figured from the south latitude tables in the same manner.

SUNRISE AND SUNSET BY NAUTICAL ALMANAC

Because the subjects sunrise and sunset are brought up here, it is appropriate to include a discussion of these times by the Nautical Almanac.

Data for finding times of sunrise, sunset, and twilight are given for latitudes between 60°S and 72°N on the daily pages of the Nautical Almanac.

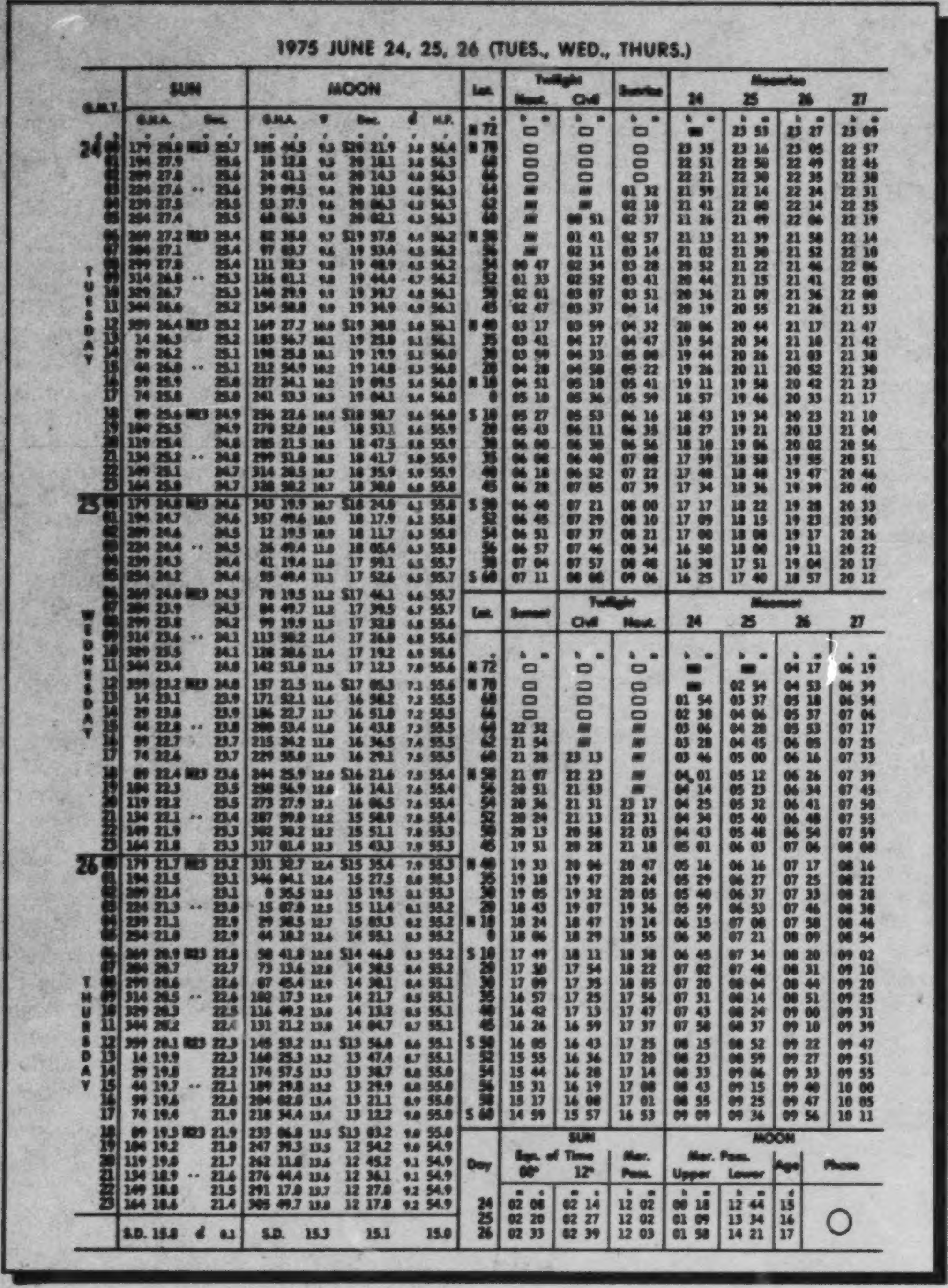
Sunrise, sunset, and the beginning and ending of twilight are given for the middle day of 3 days, and are sufficiently accurate to apply to the other 2 days. The times are applicable along any standard time meridian.

Now let's find the time of sunrise and sunset for Hampton Roads on 25 June 1975. Table 13-8 shows the right-hand page of the Nautical Almanac for the dates 24, 25, and 26 June 1975. A column headed "Sunrise" is shown on the upper right portion of the page. You see a time of sunrise tabulated for latitude 35°N (0447) and another for latitude 40°N (0432). You must interpolate between the two times for latitude 37°N. For a 5° difference in latitude (40° - 35°), you have a 15m difference in time (0447 - 0432). The latitude you want is 37°N; hence, the interpolation is two-fifths of 15m, or 6m. Sunrise is earlier as the latitude becomes higher, so sunrise at 37°N is 6m earlier than it is at 35°N. Consequently, sunrise at 37°N is 0441 (0447 - 6m). As already mentioned, time is local mean time (LMT) of sunrise. Sunrise occurs in 37°N at this LMT all the way around the world. To convert this LMT to standard time, apply the difference in longitude between your local meridian and your standard time meridian. In this example, it is the 75th.

Longitude is 76°20 ′W, which means you are 1°20 ′west of 75°W. This arc amounts to 5m 20s of time. Because you are west of the standard meridian, sunrise occurs later. Hence, zone time of sunrise where you are is 0446 (0441 + 5m).

Sunset is figured in the same manner as sunrise. Look at the sunset tables near the middle of the page in table 13-8, and you see that sunset in 35°N latitude is at 1918; in 40°N it is 1933. Your interpolation here for 37°N is two-fifths of 15m, or 6m. Here you see that sunset is later in 40°N than it is in 35°N latitude, so you add 6m to 1918, the tabulated

Table 13-8.—Sunrise and Sunset from Nautical Almanac.



1975 JUNE 24, 25, 26 (TUES., WED., THURS.)

G.M.T.	SUN G.H.A.	SUN Dec.	MOON G.H.A.	MOON v	MOON Dec.	MOON d	MOON H.P.
d h	° ′	° ′	° ′	′	° ′	′	′
24 00 TUESDAY	179 28.0	N23 25.7	355 44.5	9.3	S20 21.9	3.8	56.4
01	194 27.9	25.6	10 12.8	9.5	20 18.1	3.8	56.3
02	209 27.8	25.6	24 41.3	9.6	20 14.3	4.0	56.3
03	224 27.6	·· 25.6	39 09.5	9.6	20 10.3	4.0	56.3
04	239 27.5	25.5	53 37.9	9.6	20 06.3	4.2	56.3
05	254 27.4	25.5	68 06.5	9.5	20 02.1	4.3	56.3
06	269 27.2	N23 25.4	82 35.0	9.7	S19 57.8	4.4	56.2
07	284 27.1	25.4	97 03.7	9.6	19 53.4	4.5	56.2
08	299 27.0	25.4	111 32.3	9.8	19 48.9	4.5	56.2
09	314 26.8	·· 25.3	126 01.1	9.8	19 44.4	4.7	56.2
10	329 26.7	25.3	140 29.9	9.9	19 39.7	4.8	56.1
11	344 26.6	25.2	154 58.8	9.9	19 34.9	4.9	56.1
12	359 26.4	N23 25.2	169 27.7	10.0	S19 30.0	5.0	56.1
13	14 26.3	25.2	183 56.7	10.1	19 25.0	5.1	56.1
14	29 26.2	25.1	198 25.8	10.1	19 19.9	5.1	56.0
15	44 26.0	·· 25.1	212 54.9	10.2	19 14.8	5.3	56.0
16	59 25.9	25.0	227 24.1	10.2	19 09.5	5.4	56.0
17	74 25.8	25.0	241 53.3	10.3	19 04.1	5.4	56.0
18	89 25.6	N23 24.9	256 22.6	10.4	S18 58.7	5.6	56.0
19	104 25.5	24.9	270 52.0	10.5	18 53.1	5.6	55.9
20	119 25.4	24.8	285 21.5	10.5	18 47.5	5.8	55.9
21	134 25.2	·· 24.8	299 51.0	10.5	18 41.7	5.8	55.9
22	149 25.1	24.7	314 20.5	10.7	18 35.9	5.9	55.9
23	164 25.0	24.7	328 50.2	10.7	18 30.0	6.0	55.8
25 00 WEDNESDAY	179 24.8	N23 24.6	343 19.9	10.7	S18 24.0	6.1	55.8
01	194 24.7	24.6	357 49.6	10.9	18 17.9	6.2	55.8
02	209 24.6	24.5	12 19.5	10.9	18 11.7	6.3	55.8
03	224 24.4	·· 24.5	26 49.4	11.0	18 05.4	6.3	55.8
04	239 24.3	24.4	41 19.4	11.0	17 59.1	6.5	55.7
05	254 24.2	24.4	55 49.4	11.1	17 52.6	6.5	55.7
06	269 24.0	N23 24.3	70 19.5	11.2	S17 46.1	6.6	55.7
07	284 23.9	24.3	84 49.7	11.2	17 39.5	6.7	55.7
08	299 23.8	24.2	99 19.9	11.3	17 32.8	6.8	55.6
09	314 23.6	·· 24.1	113 50.2	11.4	17 26.0	6.8	55.6
10	329 23.5	24.1	128 20.6	11.4	17 19.2	6.9	55.6
11	344 23.4	24.0	142 51.0	11.5	17 12.3	7.0	55.6
12	359 23.2	N23 24.0	157 21.5	11.6	S17 05.3	7.1	55.6
13	14 23.1	23.9	171 52.1	11.6	16 58.2	7.2	55.5
14	29 23.0	23.9	186 22.7	11.7	16 51.0	7.2	55.5
15	44 22.8	·· 23.8	200 53.4	11.8	16 43.8	7.3	55.5
16	59 22.7	23.7	215 24.2	11.8	16 36.5	7.4	55.5
17	74 22.6	23.7	229 55.0	11.9	16 29.1	7.5	55.5
18	89 22.4	N23 23.6	244 25.9	12.0	S16 21.6	7.5	55.4
19	104 22.3	23.5	258 56.9	12.0	16 14.1	7.6	55.4
20	119 22.2	23.5	273 27.9	12.1	16 06.5	7.6	55.4
21	134 22.1	·· 23.4	287 59.0	12.2	15 58.9	7.8	55.4
22	149 21.9	23.3	302 30.2	12.2	15 51.1	7.8	55.3
23	164 21.8	23.3	317 01.4	12.3	15 43.3	7.9	55.3
26 00 THURSDAY	179 21.7	N23 23.2	331 32.7	12.4	S15 35.4	7.9	55.3
01	194 21.5	23.1	346 04.1	12.4	15 27.5	8.0	55.3
02	209 21.4	23.1	0 35.5	12.5	15 19.5	8.1	55.3
03	224 21.3	·· 23.0	15 07.0	12.5	15 11.4	8.1	55.2
04	239 21.1	22.9	29 38.5	12.7	15 03.3	8.2	55.2
05	254 21.0	22.9	44 10.2	12.6	14 55.1	8.3	55.2
06	269 20.9	N23 22.8	58 41.8	12.8	S14 46.8	8.3	55.2
07	284 20.7	22.7	73 13.6	12.8	14 38.5	8.4	55.2
08	299 20.6	22.6	87 45.4	12.9	14 30.1	8.4	55.1
09	314 20.5	·· 22.6	102 17.3	12.9	14 21.7	8.5	55.1
10	329 20.3	22.5	116 49.2	13.0	14 13.2	8.5	55.1
11	344 20.2	22.4	131 21.2	13.0	14 04.7	8.7	55.1
12	359 20.1	N23 22.3	145 53.2	13.1	S13 56.0	8.6	55.1
13	14 19.9	22.3	160 25.3	13.2	13 47.4	8.7	55.1
14	29 19.8	22.2	174 57.5	13.3	13 38.7	8.8	55.0
15	44 19.7	·· 22.1	189 29.8	13.2	13 29.9	8.8	55.0
16	59 19.6	22.0	204 02.0	13.4	13 21.1	8.9	55.0
17	74 19.4	21.9	218 34.4	13.4	13 12.2	9.0	55.0
18	89 19.3	N23 21.9	233 06.8	13.5	S13 03.2	9.0	55.0
19	104 19.2	21.8	247 39.3	13.5	12 54.2	9.0	54.9
20	119 19.0	21.7	262 11.8	13.6	12 45.2	9.1	54.9
21	134 18.9	·· 21.6	276 44.4	13.6	12 36.1	9.1	54.9
22	149 18.8	21.5	291 17.0	13.7	12 27.0	9.2	54.9
23	164 18.6	21.4	305 49.7	13.8	12 17.8	9.2	54.9
	S.D. 15.8	d 0.1	S.D. 15.3		15.1		15.0

Lat.	Twilight Naut.	Twilight Civil	Sunrise	Moonrise 24	Moonrise 25	Moonrise 26	Moonrise 27
°	h m	h m	h m	h m	h m	h m	h m
N 72	▭	▭	▭	■	23 53	23 27	23 09
N 70	▭	▭	▭	23 35	23 16	23 05	22 57
68	▭	▭	▭	22 51	22 50	22 49	22 46
66	▭	▭	▭	22 21	22 30	22 35	22 38
64	////	////	01 32	21 59	22 14	22 24	22 31
62	////	////	02 10	21 41	22 00	22 14	22 25
60	////	00 51	02 37	21 26	21 49	22 06	22 19
N 58	////	01 41	02 57	21 13	21 39	21 58	22 14
56	////	02 11	03 14	21 02	21 30	21 52	22 10
54	00 47	02 34	03 28	20 52	21 22	21 46	22 06
52	01 33	02 52	03 41	20 44	21 15	21 41	22 03
50	02 01	03 07	03 51	20 36	21 09	21 36	22 00
45	02 47	03 37	04 14	20 19	20 55	21 26	21 53
N 40	03 17	03 59	04 32	20 06	20 44	21 17	21 47
35	03 41	04 17	04 47	19 54	20 34	21 10	21 42
30	03 59	04 33	05 00	19 44	20 26	21 03	21 38
20	04 28	04 58	05 22	19 26	20 11	20 52	21 30
N 10	04 51	05 18	05 41	19 11	19 58	20 42	21 23
0	05 10	05 36	05 59	18 57	19 46	20 33	21 17
S 10	05 27	05 53	06 16	18 43	19 34	20 23	21 10
20	05 43	06 11	06 35	18 27	19 21	20 13	21 04
30	06 00	06 30	06 56	18 10	19 06	20 02	20 56
35	06 08	06 40	07 08	17 59	18 58	19 55	20 51
40	06 18	06 52	07 22	17 48	18 48	19 47	20 46
45	06 28	07 05	07 39	17 34	18 36	19 39	20 40
S 50	06 40	07 21	08 00	17 17	18 22	19 28	20 33
52	06 45	07 29	08 10	17 09	18 15	19 23	20 30
54	06 51	07 37	08 21	17 00	18 08	19 17	20 26
56	06 57	07 46	08 34	16 50	18 00	19 11	20 22
58	07 04	07 57	08 48	16 38	17 51	19 04	20 17
S 60	07 11	08 08	09 06	16 25	17 40	18 57	20 12

Lat.	Sunset	Twilight Civil	Twilight Naut.	Moonset 24	Moonset 25	Moonset 26	Moonset 27
°	h m	h m	h m	h m	h m	h m	h m
N 72	▭	▭	▭	■	■	04 17	06 19
N 70	▭	▭	▭	■	02 54	04 53	06 39
68	▭	▭	▭	01 54	03 37	05 18	06 54
66	▭	▭	▭	02 38	04 06	05 37	07 06
64	22 32	////	////	03 06	04 28	05 53	07 17
62	21 54	////	////	03 28	04 45	06 05	07 25
60	21 28	23 13	////	03 46	05 00	06 16	07 33
N 58	21 07	22 23	////	04 01	05 12	06 26	07 39
56	20 51	21 53	////	04 14	05 23	06 34	07 45
54	20 36	21 31	23 17	04 25	05 32	06 41	07 50
52	20 24	21 13	22 31	04 34	05 40	06 48	07 55
50	20 13	20 58	22 03	04 43	05 48	06 54	07 59
45	19 51	20 28	21 18	05 01	06 03	07 06	08 08
N 40	19 33	20 06	20 47	05 16	06 16	07 17	08 16
35	19 18	19 47	20 24	05 29	06 27	07 25	08 22
30	19 05	19 32	20 05	05 40	06 37	07 33	08 28
20	18 43	19 07	19 36	05 59	06 53	07 46	08 38
N 10	18 24	18 47	19 14	06 15	07 08	07 58	08 46
0	18 06	18 29	18 55	06 30	07 21	08 09	08 54
S 10	17 49	18 11	18 38	06 45	07 34	08 20	09 02
20	17 30	17 54	18 22	07 02	07 48	08 31	09 10
30	17 09	17 35	18 05	07 20	08 04	08 44	09 20
35	16 57	17 25	17 56	07 31	08 14	08 51	09 25
40	16 42	17 13	17 47	07 43	08 24	09 00	09 31
45	16 26	16 59	17 37	07 58	08 37	09 10	09 39
S 50	16 05	16 43	17 25	08 15	08 52	09 22	09 47
52	15 55	16 36	17 20	08 23	08 59	09 27	09 51
54	15 44	16 28	17 14	08 33	09 06	09 33	09 55
56	15 31	16 19	17 08	08 43	09 15	09 40	10 00
58	15 17	16 08	17 01	08 55	09 25	09 47	10 05
S 60	14 59	15 57	16 53	09 09	09 36	09 56	10 11

Day	SUN Eqn. of Time 00h	SUN Eqn. of Time 12h	SUN Mer. Pass.	MOON Mer. Pass. Upper	MOON Mer. Pass. Lower	MOON Age	MOON Phase
	m s	m s	h m	h m	h m	d	
24	02 08	02 14	12 02	00 18	12 44	15	
25	02 20	02 27	12 02	01 09	13 34	16	○
26	02 33	02 39	12 03	01 58	14 21	17	

69.146

time of sunset for 35°N. Therefore, LMT of sunset for 37°N is 1924.

In order to find ZT, you have the same 5m correction to add. Where you are, ZT of sunset is 1929 (1924 + 5m).

MOONRISE AND MOONSET

Frequently, the time of the rising and setting of the Moon is of importance. Their timing is of special significance in wartime, when the increase in visibility may make it necessary for a ship to start a zigzag, cease blowing tubes, and so on. Times of moonrise and moonset are listed in a section at the back of the Tide Tables for every day in the year for a few selected points. These times can be computed from the Nautical Almanac for any point on the Earth. The listed times in the Almanac, however, are LMT of moonrise and moonset at the Greenwich meridian. Because the Moon takes approximately 50 minutes longer than does the Sun to go all the way around the Earth, your longitude becomes a factor in calculating time of moonrise and moonset for any meridian besides Greenwich. These times may be calculated for any longitude by the steps described in the next paragraph.

Moonrise and moonset are given in the Almanac for each day for the Greenwich meridian. Precise time of either moonrise or moonset, for other longitudes, may be obtained as follows: When in east longitude, interpolate for latitude on the desired day and also on the preceding day. In west longitude, interpolate for latitude on the desired day and the following day. Take the difference between the two results, multiply it by the longitude divided by 360°, and apply the product to the tabulated time for the specified day.

As an example, let's find the time of moonrise in latitude 38°S, longitude 145°E, on 27 June 1975. You're in east longitude, so take the times for 27 June and the preceding day (26 June) thus:

	35°S	40°S
Moonrise 27 June- - - -	2051	2046
Moonrise 26 June- - - -	1955	1947

Interpolation for latitude 38°S works out as follows:

Moonrise 27 June- - - - 2048

Moonrise 26 June- - - - 1950

The difference between 2048 and 1950 is 58m. This result is multiplied by the longitude (145°E), divided by 360, or 8416/360, which gives approximately 23m. Then, 23m is the correction to be applied to the tabulated time of moonrise in 38°S for 27 June. You're in east longitude, so the correction is minus. Therefore, LMT is 2025 (2048 - 23m). To find the zone time of moonrise, apply a plus 20m longitude correction, and get 2044 (2024 + 20m).

The time of moonset is found similarly.

	35°S	38°S	40°S
Moonset 27 June- - -	0925	0929	0931
Moonset 26 June- - -	0881	0856	0900

From the foregoing data the time correction is found to be 10m. Subtracting this result from 0929 and adding the 20m longitude correction, the zone time of moonset is found to be 0939.

AIR ALMANAC

Information in the Air Almanac is similar to that in the Nautical Almanac. Sunrise/sunset and monnrise/moonset may be computed from the Air Almanac in the same manner as from the Nautical Almanac. The principal difference between the two publications is the arrangement of the tabular data given in each.

CHAPTER 14

WEATHER

The men who "go down to the sea in ships" fight a continuous close action with the elements that make up the weather. To seafarers the state of the weather is a matter of much greater importance than it is to most people ashore. Accurate weather forecasting may not be as vital now as it was in the days of the sailing ships, but situations still arise in which the safety of a ship and the lives of her crew depend on the evasive action taken to avoid the full fury of a storm. Even when actual safety is not considered, possible damage to the ship, her boats, gear, and the like, must be minimized by extra security measures taken well in advance of an approaching storm.

The action taken by ships may be based on the latest weather information compiled and broadcast by United States Navy Fleet Weather Centrals. The Weather Central bases its predictions largely upon the reports of weather conditions received from ships at sea. An intelligent weather report from a ship can be made only by a person capable of accurately observing and (to some extent) interpreting weather conditions around him. You already know that Aerographer's Mates are charged with this duty; but not all ships carry them. On a ship that doesn't have Aerographer's Mates aboard, the weather duties devolve upon the Quartermasters. This chapter, then, is concerned with the weather and the way it is observed and reported.

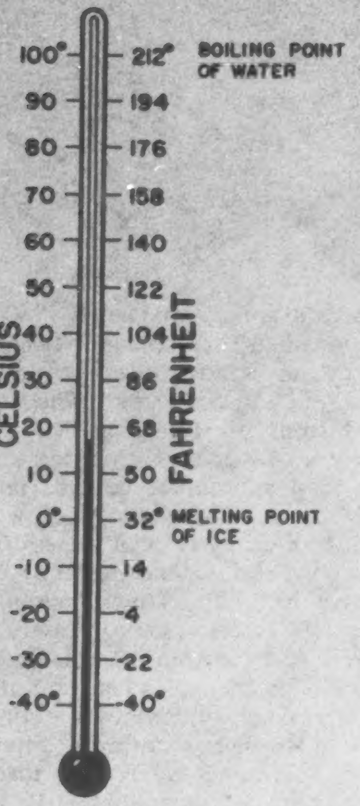
THE ATMOSPHERE

The atmosphere (air) is a mixture of independent gases. Near the surface of the Earth the percentages by volume of the various constituents are approximately 78% nitrogen, 21% oxygen, 1% argon, with traces of other gases such as carbon dioxide, hydrogen, neon, and helium. Water vapor, which has been omitted from the foregoing list, is found in relatively small but widely varying amounts; 1% of the total atmosphere may be taken as the average figure. The quantity of water vapor present is much greater in equatorial regions than in polar regions, and greater over the ocean than over land. The atmosphere has definite weight, called atmospheric pressure, and it is measured by an instrument called a barometer.

Large-scale changes in temperature, pressure, and water vapor content of the air cause the changes in weather. Warm air is lighter in weight and can hold more water vapor than cold air. Moist air with a temperature of 50°F is lighter than drier air of the same temperature because water vapor is lighter than air. Cold or heavy air has a tendency to flow toward and supplant warm or lighter air, and as the air begins to move, other forces come into play, making the movement of air masses and weather rather complex. You can readily see, however, that temperature, humidity, and atmospheric pressure are all factors in considering the weather.

MEASURING TEMPERATURE

You probably don't need to be told that a thermometer is an instrument for measuring temperature. Generally speaking, it is a glass tube of small bore in which either alcohol or mercury expands and contracts with the rise and fall of the temperature of the surrounding medium.



33.11(69)

Figure 14-1.—Celsius and Fahrenheit scales.

Most Navy thermometers are mercury-filled and practically all of them use the Fahrenheit (F) scale, in which the freezing point of water is 32° and its boiling point is 212°. Temperature in meteorology, however, sometimes is expressed according to the Celsius (C) (formerly Centigrade) scale, in which the freezing point of water is 0° and its boiling point is 100° (figure 14-1.)

You might be required to convert a Fahrenheit reading to Celsius, or vice versa. Figure 14-1 shows that on the two scales there are 5° of Celsius temperature to every 9° of Fahrenheit.

Inasmuch as 32°F is equivalent to 0°C, to change a Fahrenheit reading to Celsius you first subtract 32° and then multiply the remainder by 5/9. Say you want to change 41°F to Celsius. Subtracting 32° from 41° gives 9°. Multiply 9° by 5/9, and you get 45/9, or 5°C.

To change from Celsius to Fahrenheit, simply reverse the procedure. First multiply the Celsius temperature by 9/5, then add 32°. In the previous example, to change 5°C back to Fahrenheit, first multiply it by 9/5, which gives you 45/5, or 9°. Adding 32° gives you 41°F.

READING A THERMOMETER

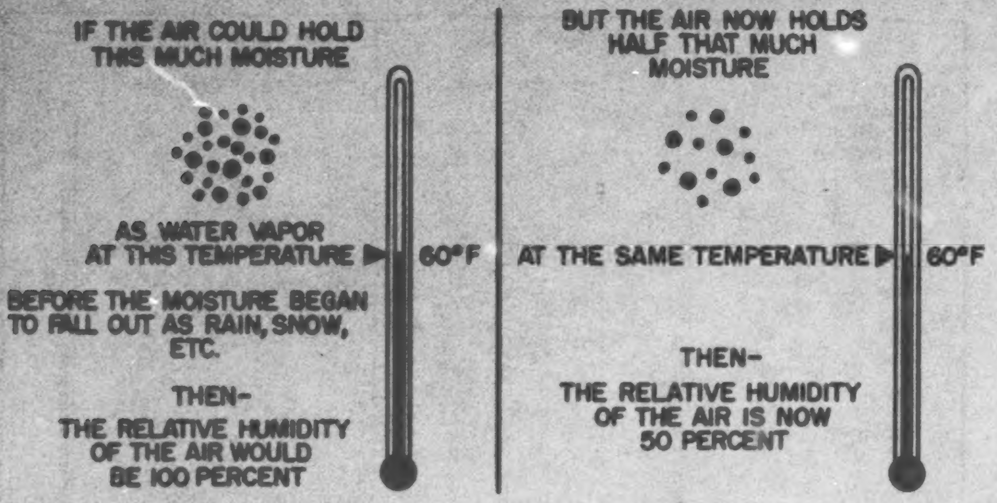
A thermometer must be read properly to obtain an accurate result. First, if you must handle it, be sure that you do not touch the lower part of the glass containing the alcohol or mercury, because the heat from your body can affect the height of the mercury or alcohol column. Make certain that the top of the column is level with your eyes; otherwise you will be reading a higher or lower graduation than the one actually indicated. The top of the column is in the shape of a curve called a meniscus. It is the bottom of this curve that indicates the reading for an alcohol thermometer; the top, for a mercury thermometer.

MEASURING DEWPOINT AND RELATIVE HUMIDITY

As already mentioned, the amount of water vapor the atmosphere can hold varies with the temperature. When the atmosphere contains all the water it can hold for a given temperature, humidity is at the saturation point, or 100%. If it contains 50% of what it could hold at that particular temperature, relative humidity is 50% (figure 14-2). Relative humidity and dewpoint are determined through use of a psychrometer.

PSYCHROMETER

A psychrometer is simply two ordinary thermometers mounted together on a single strip of material. (See figure 14-3.) The bulb of one thermometer is covered by a water-soaked wick from which the water evaporates rapidly or slowly, depending on the amount of water vapor in the surrounding atmosphere. Evaporation of water around the wet thermometer cools it. The


IF THE AIR COULD HOLD
THIS MUCH MOISTURE
AS WATER VAPOR
AT THIS TEMPERATURE ▶ 60°F
BEFORE THE MOISTURE BEGAN
TO FALL OUT AS RAIN, SNOW,
ETC.
THEN-
THE RELATIVE HUMIDITY
OF THE AIR WOULD
BE 100 PERCENT
BUT THE AIR NOW HOLDS
HALF THAT MUCH
MOISTURE
AT THE SAME TEMPERATURE ▶ 60°F
THEN-
THE RELATIVE HUMIDITY
OF THE AIR IS NOW
50 PERCENT

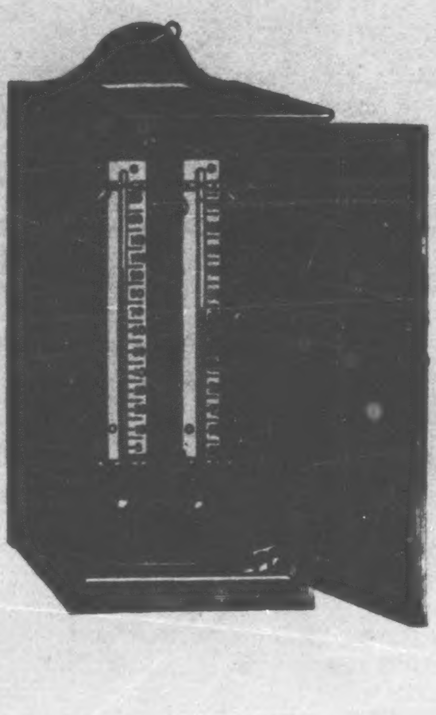
69.83

Figure 14-2.—Relative humidity.

amount of cooling depends on the rate of evaporation. The reading on the wet bulb is lower than the reading on the dry bulb except when the humidity is 100%, at which time both readings coincide. The difference between the wet-bulb and dry-bulb readings, when applied to tables developed for that purpose, results in relative humidity and dewpoint temperature. The dewpoint is the temperature to which air must be cooled at constant pressure and constant water vapor content to reach saturation (100% relative humidity). When air is cooled to its dewpoint temperature, small water droplets condense on objects; i.e., dew forms. (See figure 14-4.)

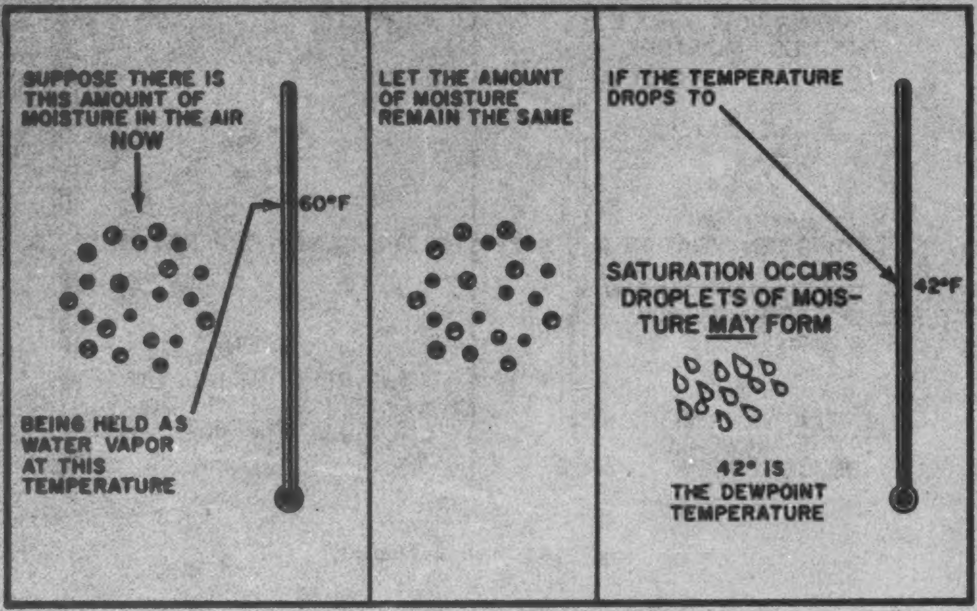
Sling Psychrometer

A sling psychrometer (figure 14-5) sometimes is used to speed up the process of getting accurate wet- and dry-bulb readings. The sling psychrometer can be whirled around so as to rapidly bring the wet bulb into contact with a great volume of air. This contact with air accelerates the evaporation rate. The person using the sling psychrometer should face the wind and should shield the instrument as much as possible from the direct rays of the Sun. Whirling should not be too rapid because centrifugal force might displace the mercury



69.84

Figure 14-3.—Psychrometer.


SUPPOSE THERE IS
THIS AMOUNT OF
MOISTURE IN THE AIR
NOW
60°F
BEING HELD AS
WATER VAPOR
AT THIS
TEMPERATURE
LET THE AMOUNT
OF MOISTURE
REMAIN THE SAME
IF THE TEMPERATURE
DROPS TO
SATURATION OCCURS
DROPLETS OF MOISTURE MAY FORM
42°F
42° IS
THE DEWPOINT
TEMPERATURE

69.85

Figure 14-4.—Dewpoint.

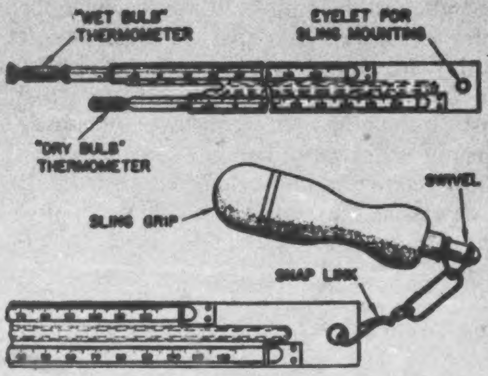
columns in the thermometers. The whirling should be repeated until no further change can be detected in the wet-bulb reading.

DEWPOINT

The dewpoint is computed by using the psychrometer table shown in table 14-1. (More complete tables may be found in NAVWEASERVCOMINST 3144.1( ), *Manual for Ship's Surface Weather Observations.*) Take, for example, a dry-bulb temperature of 60°F and a wet-bulb temperature of 50.5°F. The difference between the two readings is 9.5°F. This difference is called the depression of the wet bulb.

To compute the dewpoint, enter the table with the wet-bulb reading (50.5°F). Read across the top of the table to the proper depression column (9.5°F). Read the dewpoint temperature (42°F) directly from the intersection of the temperature row and the depression column.

ATMOSPHERIC PRESSURE


"WET BULB"
THERMOMETER
EYELET FOR
SLING MOUNTING
"DRY BULB"
THERMOMETER
SWIVEL
SLING GRIP
SNAP LINK

5.65(69)C

Figure 14-5.—Sling psychrometer.

The layer of atmosphere that surrounds us exerts a pressure of approximately 15 pounds per square inch at the Earth's surface. The weight of the atmosphere varies with the presence of water vapor as well as with temperature and height above the Earth's surface. Variations in atmospheric pressure are measured by an instrument called a barometer.

Table 14-1.—Psychrometric Table

Wet-bulb temperature (°F.)	Depression of the wet-bulb thermometer (dry-bulb minus wet-bulb)																			
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
50.0	50	49	49	48	48	47	47	47	46	46	45	45	44	44	43	43	42	41	41	40
50.5	50	50	49	49	48	48	48	47	47	46	46	45	45	44	44	43	43	42	42	41
51.0	51	50	50	49	49	49	48	48	47	47	46	46	45	45	44	44	43	43	42	42
51.5	51	51	50	50	49	49	49	48	48	47	47	46	46	45	45	44	44	43	43	42
52.0	52	51	51	50	50	50	49	49	48	48	47	47	46	46	46	45	45	44	44	43
52.5	52	52	51	51	51	50	50	49	49	48	48	48	47	47	46	46	45	45	44	44
53.0	53	52	52	51	51	51	50	50	49	49	49	48	48	47	47	46	46	45	45	44
53.5	53	53	52	52	52	51	51	50	50	50	49	49	48	48	47	47	46	46	46	45
54.0	54	53	53	53	52	52	51	51	51	50	50	49	49	48	48	48	47	47	46	46
54.5	54	54	53	53	53	52	52	51	51	51	50	50	49	49	49	48	48	47	47	46
55.0	55	54	54	54	53	53	52	52	52	51	51	50	50	50	49	49	48	48	47	47
55.5	55	55	54	54	54	53	53	53	52	52	51	51	51	50	50	49	49	49	48	48
56.0	56	55	55	55	54	54	54	53	53	52	52	52	51	51	50	50	50	49	49	48
56.5	56	56	55	55	55	54	54	54	53	53	53	52	52	51	51	51	50	50	49	49
57.0	57	56	56	56	55	55	55	54	54	54	53	53	52	52	52	51	51	50	50	50
57.5	57	57	57	56	56	55	55	55	54	54	54	53	53	53	52	52	51	51	51	50
58.0	58	57	57	57	56	56	56	55	55	55	54	54	54	53	53	52	52	52	51	51
58.5	58	58	58	57	57	57	56	56	56	55	55	54	54	54	53	53	53	52	52	51
59.0	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	54	53	53	52	52
59.5	59	59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	53	53	53

Table 14-1.—Psychrometric Table

Depression of the wet-bulb thermometer (dry-bulb minus wet-bulb)																			
1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5
49	49	48	48	47	47	47	46	46	45	45	44	44	43	43	42	41	41	40	40
50	49	49	48	48	48	47	47	46	46	45	45	44	44	43	43	42	42	41	40
50	50	49	49	49	48	48	47	47	46	46	45	45	44	44	43	43	42	42	41
51	50	50	49	49	49	48	48	47	47	46	46	45	45	44	44	43	43	42	42
51	51	50	50	50	49	49	48	48	47	47	46	46	46	45	45	44	44	43	43
52	51	51	51	50	50	49	49	48	48	48	47	47	46	46	45	45	44	44	43
52	52	51	51	51	50	50	49	49	49	48	48	47	47	46	46	45	45	44	44
53	52	52	52	51	51	50	50	50	49	49	48	48	47	47	46	46	46	45	45
53	53	53	52	52	51	51	51	50	50	49	49	48	48	48	47	47	46	46	45
54	53	53	53	52	52	51	51	51	50	50	49	49	49	48	48	47	47	46	46
54	54	54	53	53	52	52	52	51	51	50	50	50	49	40	48	48	47	47	47
55	54	54	54	53	53	53	52	52	51	51	51	50	50	49	49	49	48	48	47
55	55	55	54	54	54	53	53	52	52	52	51	51	50	50	50	49	49	48	48
56	55	55	55	54	54	54	53	53	53	52	52	51	51	51	50	50	49	49	48
56	56	56	55	55	55	54	54	54	53	53	52	52	52	51	51	50	50	50	49
57	57	56	56	55	55	55	54	54	54	53	53	53	52	52	51	51	51	50	50
57	57	57	56	56	56	55	55	55	54	54	54	53	53	52	52	52	51	51	50
58	58	57	57	57	56	56	56	55	55	54	54	54	53	53	53	52	52	51	51
58	58	58	57	57	57	56	56	56	55	55	55	54	54	54	53	53	52	52	52
59	59	58	58	58	57	57	57	56	56	56	55	55	55	54	54	53	53	53	52

69.132

The Navy uses two types of barometers: mercurial and aneroid.

MERCURIAL BAROMETER

The mercurial barometer is a mercury-filled glass tube which has been accurately calibrated. It is used at shore activities to check aneroid barometers for accuracy.

ANEROID BAROMETER

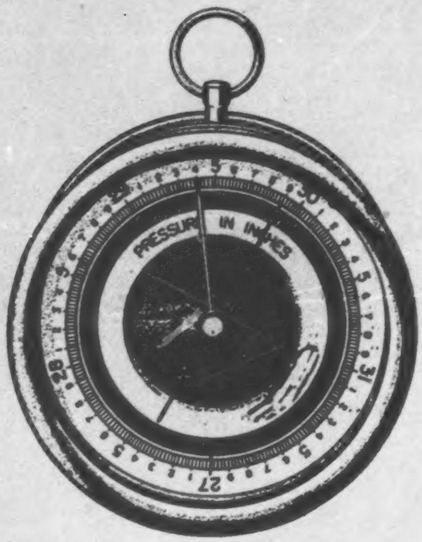
The aneroid ("dry" or "no fluid") barometer (figure 14-6) needs no correction except for altitude. It contains a small metallic cell, called a sylphon cell, which encloses a partial vacuum. As atmospheric pressure increases, the sylphon contracts; as pressure decreases, it expands. As the sylphon expands and contracts, it communicates motion to an indicating pointer on a graduated scale.

A stationary needle on the aneroid barometer may be fixed at any point so as to show the tendency (rise, fall, or steadiness) of the barometer since the last reading.

Mercurial-Aneroid Comparison

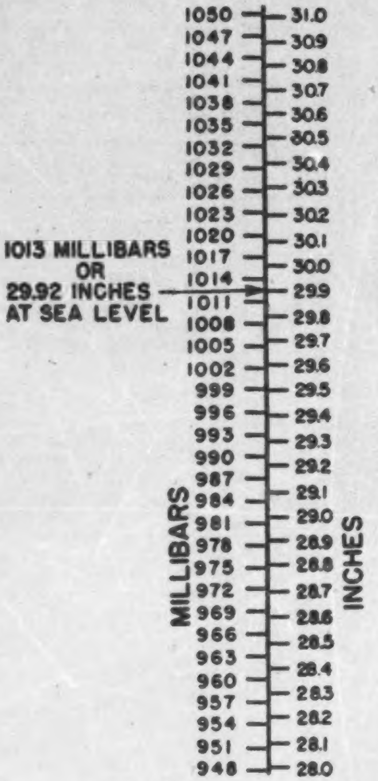
Barometers may be graduated in either inches of mercury of millibars (mbs). Both inches and millibars are linear measurements of the height of the mercury column supported by the atmosphere at a given time. The average atomspheric pressure at the Earth's surface is 29.92 inches or 1013.2 millibars. Figure 14-7 shows comparative readings on the inch and millibar scales.

Although mercurial barometers may, by using a vernier, be read to the nearest 0.002


PRESSURE IN INCHES
28
27
31

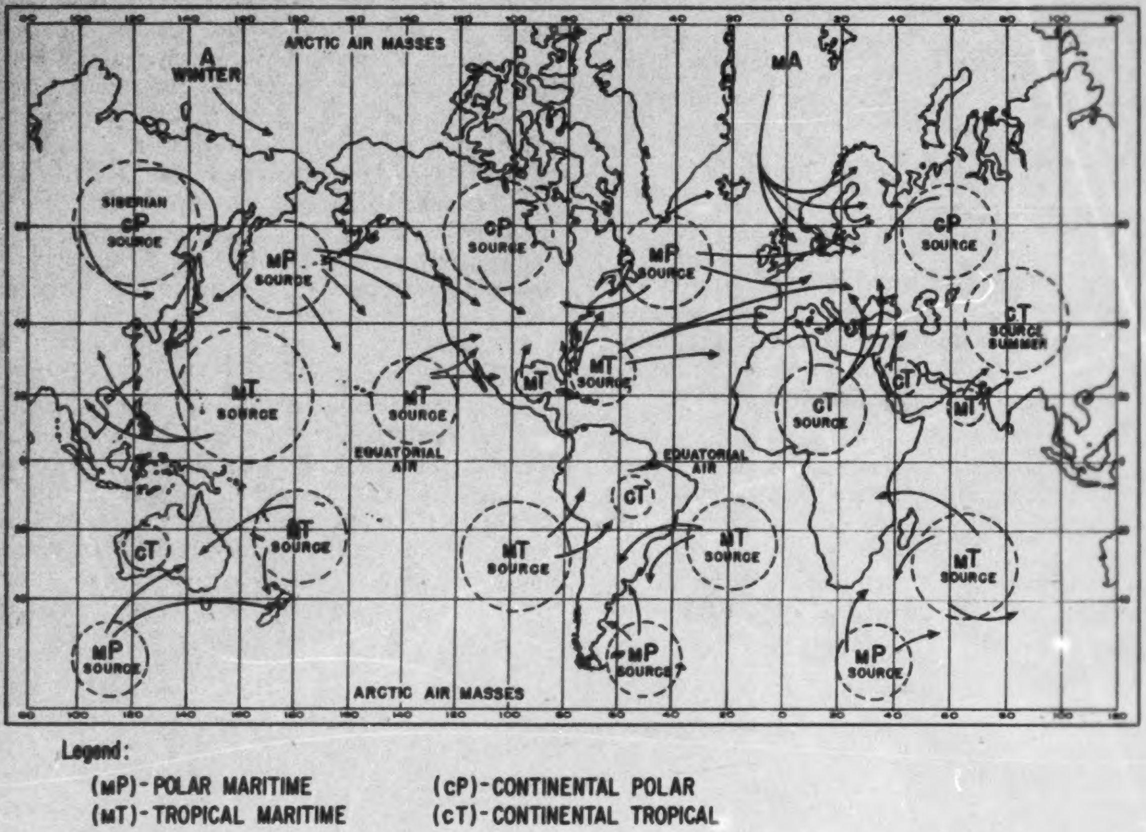
69.37

Figure 14-6.—Aneroid barometer.


1013 MILLIBARS
OR
29.92 INCHES
AT SEA LEVEL
MILLIBARS
INCHES
1050
1047
1044
1041
1038
1035
1032
1029
1026
1023
1020
1017
1014
1011
1008
1005
1002
999
996
993
990
987
984
981
978
975
972
969
966
963
960
957
954
951
948
31.0
30.9
30.8
30.7
30.6
30.5
30.4
30.3
30.2
30.1
30.0
29.9
29.8
29.7
29.6
29.5
29.4
29.3
29.2
29.1
29.0
28.9
28.8
28.7
28.6
28.5
28.4
28.3
28.2
28.1
28.0

69.88

Figure 14-7.—Inches and millibars.


ARCTIC AIR MASSES
A WINTER
MA
SIBERIAN cP SOURCE
mP SOURCE
cP SOURCE
mP SOURCE
cP SOURCE
cT SOURCE SUMMER
mT SOURCE
mT SOURCE
mT
mT SOURCE
cT SOURCE
cT
mT
EQUATORIAL AIR
EQUATORIAL AIR
cT
cT
mT SOURCE
mT SOURCE
mT SOURCE
mT SOURCE
mP SOURCE
mP SOURCE
mP SOURCE
ARCTIC AIR MASSES
Legend:
(mP)-POLAR MARITIME
(mT)-TROPICAL MARITIME
(cP)-CONTINENTAL POLAR
(cT)-CONTINENTAL TROPICAL

58.97(69)A

Figure 14-8.—Distribution of air masses.

inch, and aneroid barometers normally can be read no closer than 0.01 inch, aneroid barometers are the standard pressure-indicating instrument aboard ship and the type of barometers that Quartermasters will encounter most frequently.

The accuracy of a properly adjusted aneroid barometer is comparable to that of a mercurial barometer. Moreover, the aneroid barometer is free of the numerous corrections that must be applied to the mercurial barometer.

SIGNIFICANCE OF ATMOSPHERIC PRESSURE

A chart of the atmospheric pressure over a large area of the Earth's surface at any given time tells you which way different air masses (masses of air which have common temperature and humidity characteristics) are moving. Some air masses originate in the cold polar regions; some, in the tropics. By the time they reach you, some air masses have moved from vast bodies of water (called maritime air masses). Others (called continental air masses) have grown up over more or less dry land. Figure 14-8 pictures this distribution of air masses.

Air masses carry along with them the temperature and humidity characteristics of the areas they crossed. Where distinctly different air masses touch, the boundary between them is called a front and is marked by cloudiness and precipitation.

PRESSURE AREAS

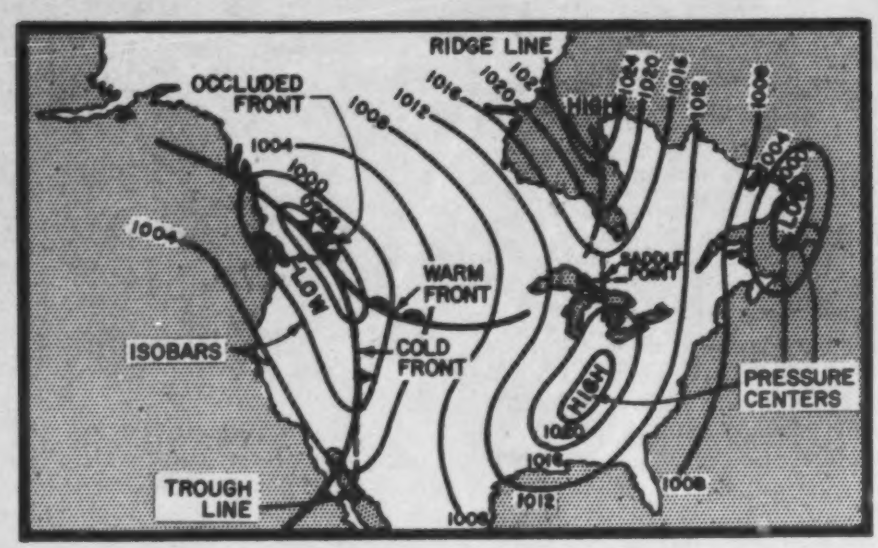
The atmosphere can produce weather in other ways, of course; but frontal weather, which usually is quite violent, can be predicted from a chart of the pressure systems. Figure 14-9 shows types of frontal systems on a weather map.

Atmospheric pressure is reported in inches of mercury or millibars. One atmosphere equals 14.696 psi, a bar equals slightly more than 0.98 atmosphere, and a millibar equals 1/1000 of a bar. On weather charts pressure usually is indicated in millibars (figure 14-9). The lines shown in the figure are drawn through points of equal pressure and are called isobars.

Assume, for example, that barometric pressure is the same in Chicago, Milwaukee, and St. Paul. An isobar is drawn through these and other points of equal pressure. Usually, isobars are drawn for equal intervals of pressure (every four millibars for example) and frequently isobars do not pass through reporting stations (figure 14-10).

Isobars never join or cross. Some may run off the chart, but others may close, forming irregular ovals that define the areas of highest and lowest pressure (figure 14-11). Air (wind) flows from high-pressure areas to low-pressure areas.

The strength of the wind depends upon two factors: the amount of difference in pressure and the distance of the high-pressure area (high) from the low-pressure area (low). These two factors combined are called pressure gradient. The greater the gradient, the stronger the wind. Thus, isobars can give a rough indication of the amount of wind. The closer an isobar is to another, the stronger the wind in that area. In



58.97(69)B

Figure 14-9.—Sample weather map showing frontal systems.

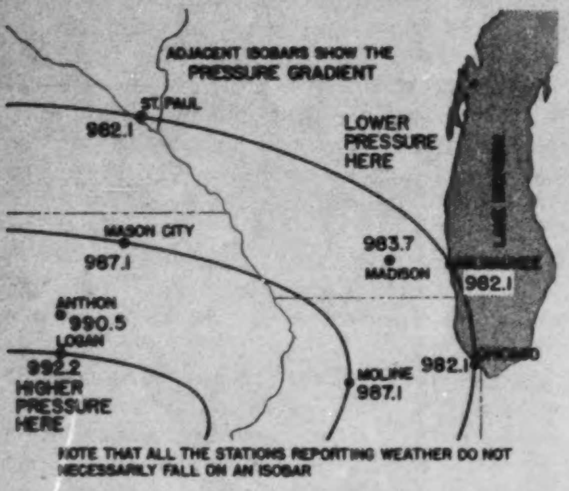

ADJACENT ISOBARS SHOW THE PRESSURE GRADIENT
ST. PAUL
982.1
LOWER PRESSURE HERE
MASON CITY
987.1
983.7
MADISON
MILWAUKEE
982.1
LAKE MICHIGAN
ANTHON
990.5
LOGAN
992.2
HIGHER PRESSURE HERE
MOLINE
987.1
982.1
CHICAGO
NOTE THAT ALL THE STATIONS REPORTING WEATHER DO NOT NECESSARILY FALL ON AN ISOBAR
69.90

Figure 14-10.—Plotting isobars.

figure 14-10, the isobars represent pressures of 992.2 mbs, 987.1 mbs, and 982.1 mbs.

Widely separated isobars indicate light winds; isobars closer together mean greater wind velocity. The spacing and shape of isobars are seen in figure 14-11, which also shows how complete isobars are formed. They're always smoothed-out curves, usually making irregular ovals about the high- or low-pressure center.

Referring again to figure 14-10 you can see that only part of each isobar (the upper right portion of the oval) appears in the diagram. In this pressure system that area of greatest pressure is at the system center. This high-pressure area is also called a high or an anticyclone. If the pressure should be 992.2 mbs at Chicago, 987.1 mbs at Moline, and 982.1 mbs at Logan, the area of lowest pressure would be in the vicinity of Logan. This area would be a low, or a cyclone.

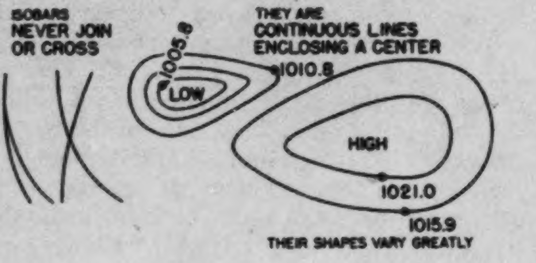

ISOBARS NEVER JOIN OR CROSS
1005.8
LOW
THEY ARE CONTINUOUS LINES ENCLOSING A CENTER
1010.8
HIGH
1021.0
1015.9
THEIR SHAPES VARY GREATLY
69.91

Figure 14-11.—Shapes of isobars.

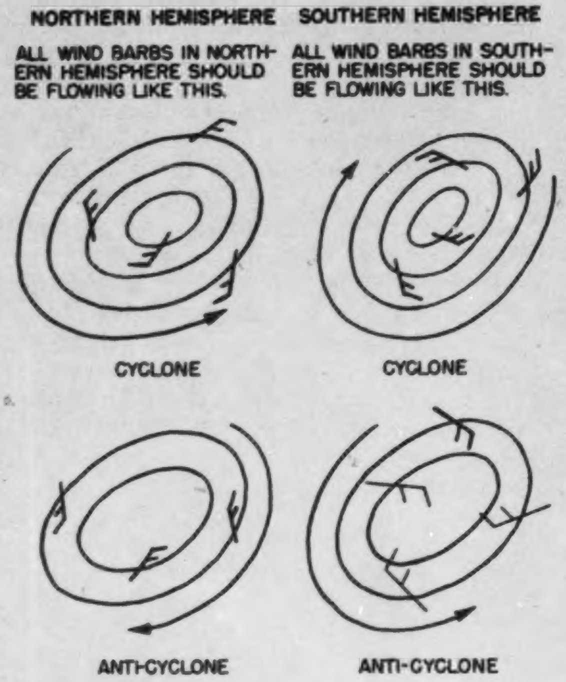

NORTHERN HEMISPHERE
SOUTHERN HEMISPHERE
ALL WIND BARBS IN NORTHERN HEMISPHERE SHOULD BE FLOWING LIKE THIS.
ALL WIND BARBS IN SOUTHERN HEMISPHERE SHOULD BE FLOWING LIKE THIS.
CYCLONE
CYCLONE
ANTI-CYCLONE
ANTI-CYCLONE
69.92

Figure 14-12.—Wind flow around high- and low-pressure areas.

AIR IN MOTION

In a high-pressure area, the air at the center flows outward. In a low, the air flows inward. This flow is not, however, strictly outward or inward. The Earth's rotation deflects the air, so that in reality it flows more or less tangent to the isobars, as in figure 14-12.

In the northern hemisphere this almost circular movement of the air is clockwise and away from the center of a high, but counterclockwise and toward the center of a low. In the southern hemisphere, the reverse movement occurs.

The little symbols that cross the isobars in figure 14-12 indicate wind direction and velocity. They're like arrows except that they have no head and only half a tail. The long arm of each symbol points, like an arrow, in the direction of the wind flow. Some of the symbols have one tail feather, some two, and some three. Each long feather represents 10 knots of wind; each short feather, 5 knots. Thus, an arrow with one long and one short feather indicates wind velocity of 15 knots; an arrow with four long feathers indicates 40 knots of wind.

The flow of air is influenced not only by the pressure and the Earth's rotation but also by friction against the Earth's surface. This friction, which slows down air motion, is greatest over land areas, especially where there is abrupt mountainous terrain.

Just as the air within the low or the high rotates as described above, the whole circulation of air also moves. Consider the weather charts for several days in a row. On the first day a low may appear over the Pacific Coast region. The chart for the next day probably shows it somewhere in the Rocky Mountain region. A day or two later it may be over Arkansas. If it has not broken up by this time, it moves on eastward and northward, and eventually dissipates over the North Atlantic. All lows in the United States do not follow this same track, however. Some lows come up from the West Indies, as you will see presently.

TROPICAL CYCLONE

You may have thought of a cyclone as being always a violent windstorm. Meterologists use this term for any low-pressure area. The furious, destructive disturbance (called a typhoon, in the Orient, and a hurricane in the West Indies) is referred to sometimes by weather experts as a tropical cyclone. Fully developed, the tropical cyclone consists of a well-defined area, more or less circular in shape, throughout which the atmospheric pressure diminishes rapidly on all sides toward the center.

Within this area the winds blow with great force. Rainfall is very heavy, especially toward the center. The motion of the air suggests on a gigantic scale the path followed by air in a whirlwind or water in a waterspout. Winds circulate counterclockwise around the center in the northern hemisphere, clockwise in the southern hemisphere. At the center itself (the eye of the storm) the dense canopy of cloud that overhangs the rest of the storm area is pierced, and calm or light air prevails, but the sea here is usually very heavy. This eye ranges from 4 to 30 miles in diameter.

Tropical cyclones occur in the North Atlantic, the North and South Pacific, and the Indian Ocean. Due to the proximity of the African and South American land masses, the South Atlantic is free of such disturbances. The general track of a tropical cyclone in the northern hemisphere is a line running first westward from the point of origin, then curving toward the north, and finally recurving to the northeast. By this time it probably has reached middle latitude, and beyond this point it usually loses its force and is spent. Such a track is diagrammed in figure 14-13.

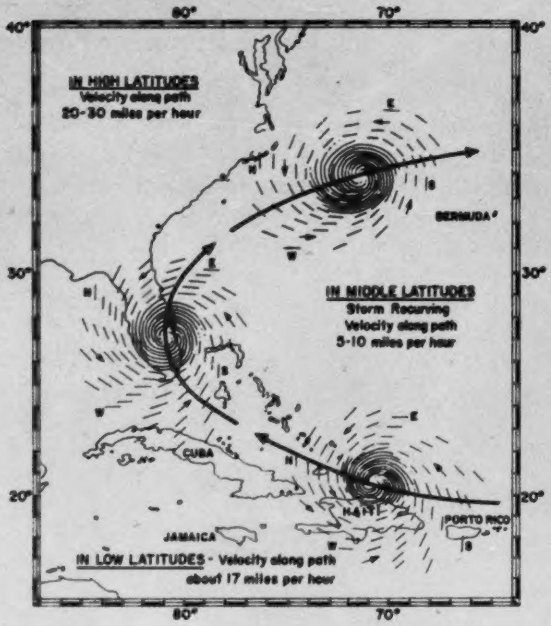


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Figure 14-13.—Track of a tropical cyclone originating in the West Indies.

The clockwise movement of air around a low in the southern hemisphere produces a corresponding reversal of the storm track in that region. The diagram in figure 14-14 illustrates this point.

RECORDING THE WEATHER

The weather observation sheet of the deck log contains weather data necessary for making log entries. Detailed instructions for making entries in the weather observation sheet are contained in the *Manual for Ship's Surface Weather Observations*, NAVWEASERVCOMINST 3144.1( ). Use this instruction—don't make up your own rules.

When the synoptic observations have been taken and recorded in the weather observation sheet, they must be radioed to Fleet Weather Centrals. Before the synoptic observations are sent, however, they must be put in proper message format. The coding system employed also can be found in the Manual For Ship's Surface Weather Observations. The message consists of five-digit groups, preceded by the message classification and the word "ship." When ice is observed, the plain language work "ice" must be inserted before the ice group. The coded groups may be taken directly from the synoptic observations table of the weather observation sheet. A sample weather observation sheet is shown in figure 14-15. A sample weather message is as follows:

BT UNCLAS SHIP 99185 70654 19094
20812 98011 16224 25500 62710 0//20
12605 3//// BT

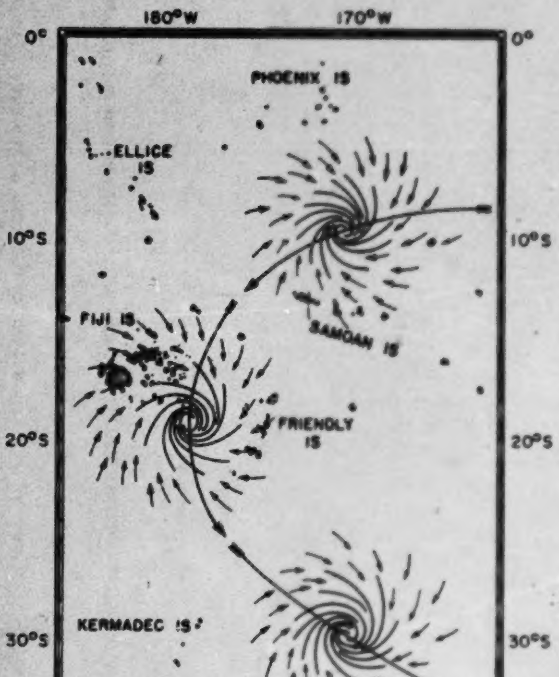

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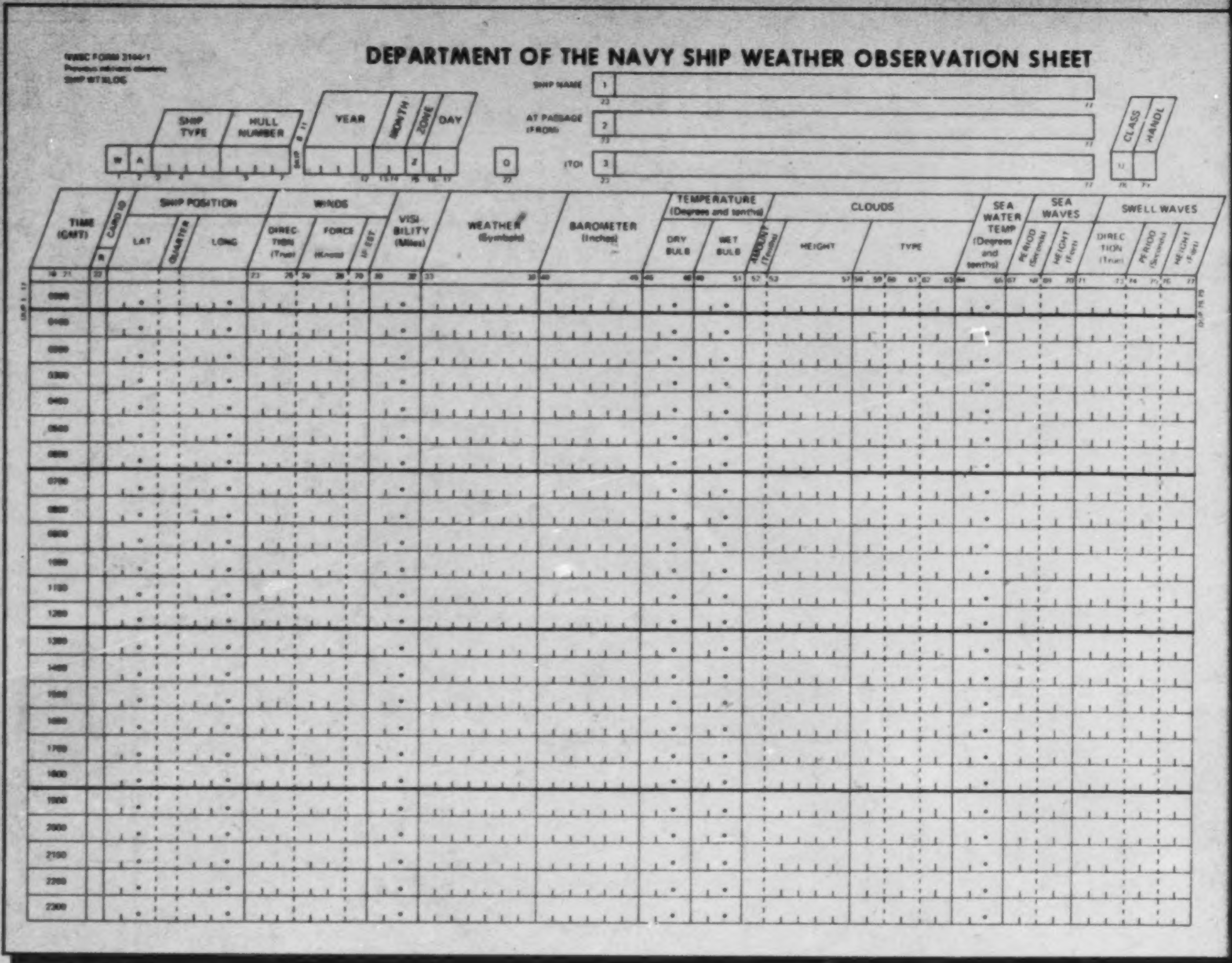
Figure 14-14.—Track of a tropical cyclone in the South Pacific.

On larger ships an Aerographer's Mate usually has elaborate equipment for weather observations. He draws up complete weather charts, which require special technical knowledge and familiarity with weather codes. You cannot be expected to make up one of these complete charts, but you must be able to assist the OOD and the navigator in intelligent observations of the weather.

The shortest route to a reliable prediction of bad weather is to keep a close and accurate record of atmospheric pressure and wind. You won't hit it on the nose every time, but frequently you won't be far off. The low-pressure area (cyclone) carries bad weather around with it, from a light storm—with only mild precipitation and wind—to the furious tropical cyclone. Usually it is good practice to keep away from the center of a low. To do so, you must know (1) whether you are moving from higher pressures to lower pressures, and (2) which way the center of the low is moving.

When regular radio weather reports are received, you can plot the pressure picture on a chart. Even if you must depend on your own observations, you can get a fairly reliable indication of what lies ahead.

During the day the pressure-indicating needle of your barometer rises and falls twice. This variation is called diurnal (daily) change and is a normal condition of the atmosphere, due to heating and cooling of the Earth's



NWSC FORM 3144/1
Previous editions obsolete
SHIP WTHLOG

DEPARTMENT OF THE NAVY SHIP WEATHER OBSERVATION SHEET

W A SHIP TYPE HULL NUMBER YEAR MONTH ZONE Z DAY 0

SHIP NAME 1
AT PASSAGE (FROM) 2
(TO) 3

CLASS U HANDL

TIME (GMT)	CARD ID 8	SHIP POSITION LAT	QUARTER	LONG	WINDS DIRECTION (True)	FORCE (Knots)	IF EST	VISIBILITY (Miles)	WEATHER (Symbols)	BAROMETER (Inches)	TEMPERATURE (Degrees and tenths) DRY BULB	WET BULB	CLOUDS AMOUNT (Tenths)	HEIGHT	TYPE	SEA WATER TEMP (Degrees and tenths)	SEA WAVES PERIOD (Seconds)	HEIGHT (Feet)	SWELL WAVES DIRECTION (True)	PERIOD (Seconds)	HEIGHT (Feet)
0000																					
0100																					
0200																					
0300																					
0400																					
0500																					
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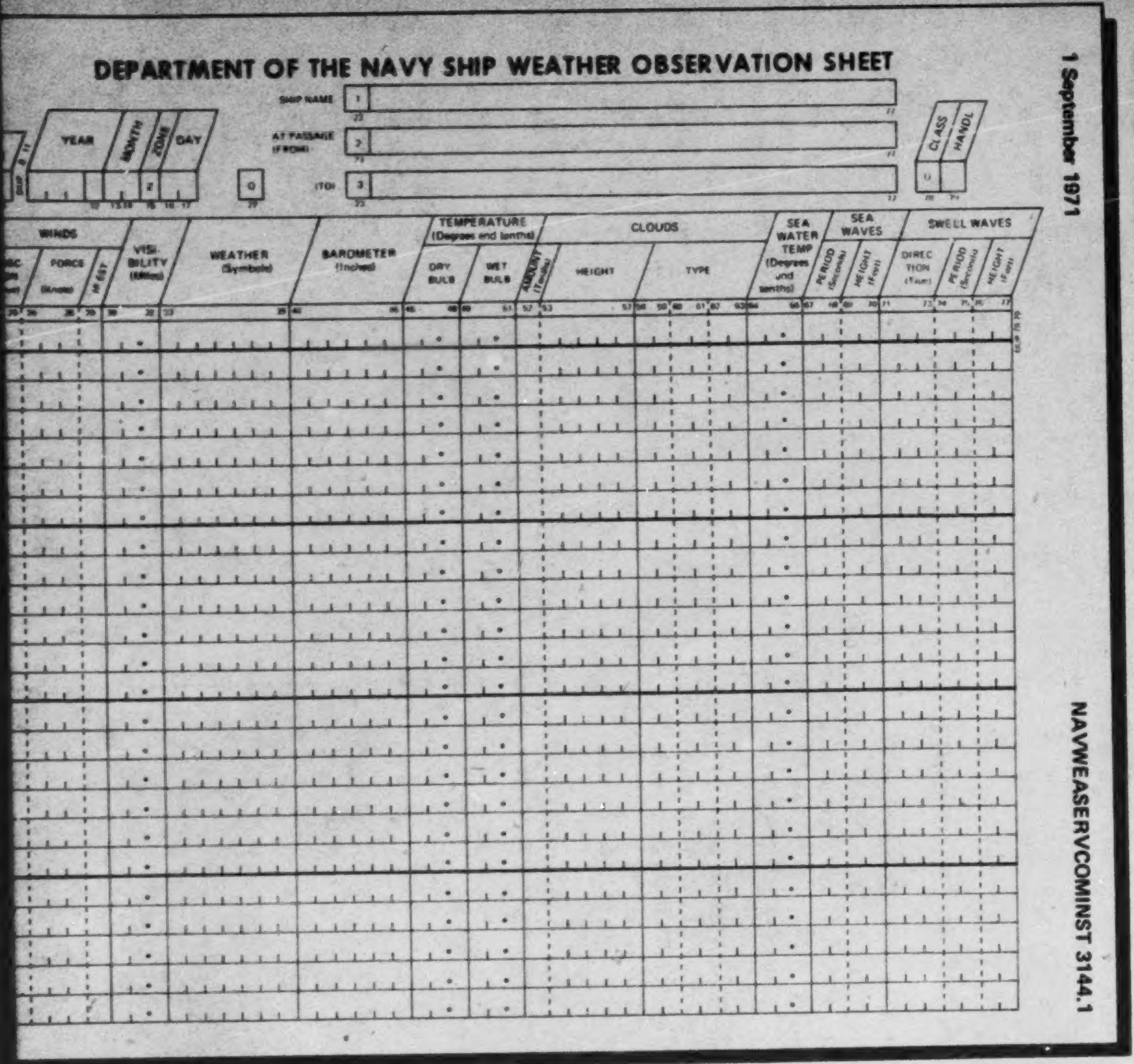
Figure 14-15.—Department of the Navy Ship Weather Observation Sheet.



DEPARTMENT OF THE NAVY SHIP WEATHER OBSERVATION SHEET

SHIP NAME 1

AT PASSAGE (FROM) 2

(TO) 3

YEAR

MONTH

ZONE Z

DAY

0

CLASS 0

HANDL

WINDS: FORCE (Knots); IF EST

VISIBILITY (Miles)

WEATHER (Symbols)

BAROMETER (Inches)

TEMPERATURE (Degrees and tenths): DRY BULB; WET BULB

CLOUDS: AMOUNT (Tenths); HEIGHT; TYPE

SEA WATER TEMP (Degrees and tenths)

SEA WAVES: PERIOD (Seconds); HEIGHT (Feet)

SWELL WAVES: DIRECTION (True); PERIOD (Seconds); HEIGHT (Feet)

1 September 1971

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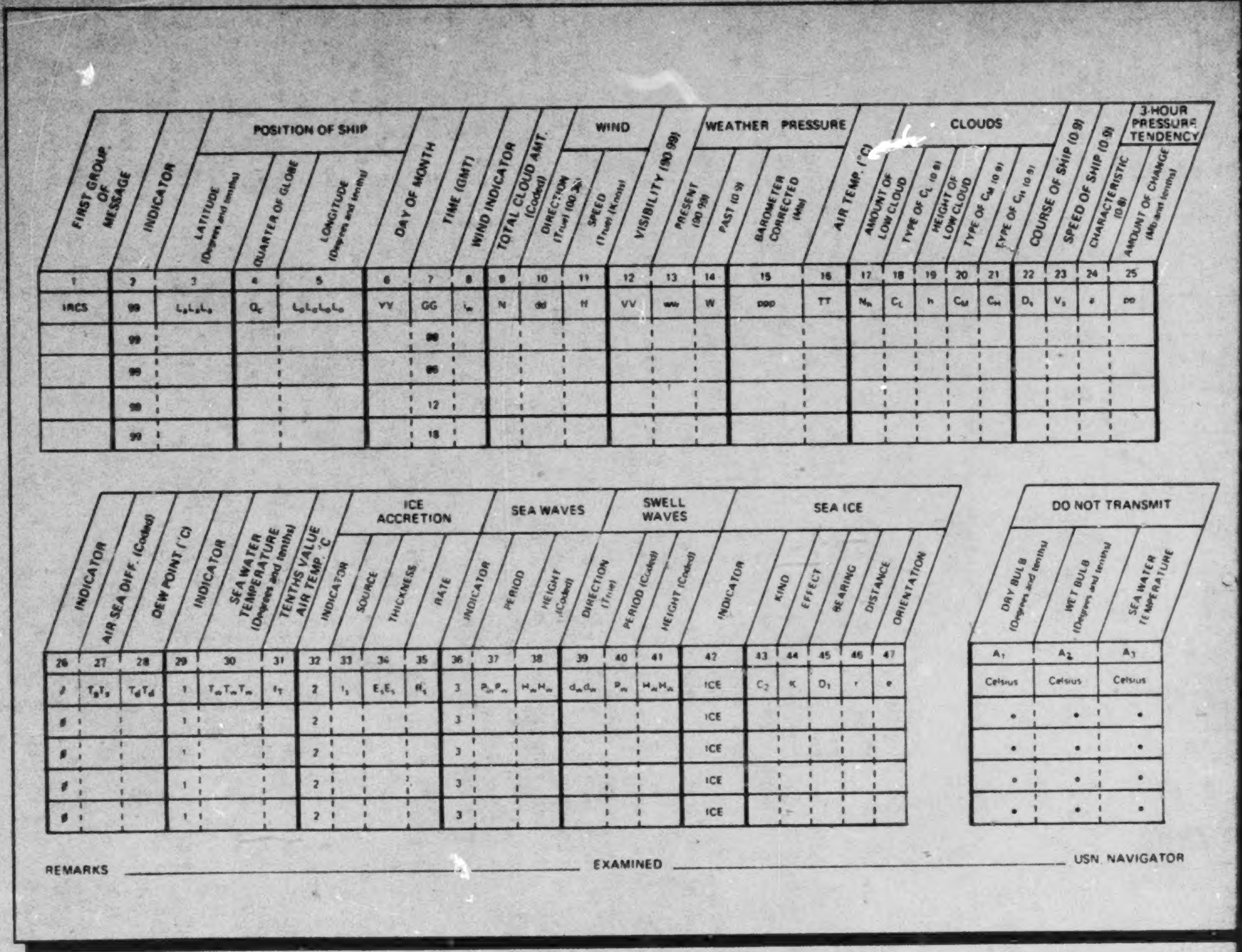
igure 14-15.—Department of the Navy Ship Weather Observation Sheet.



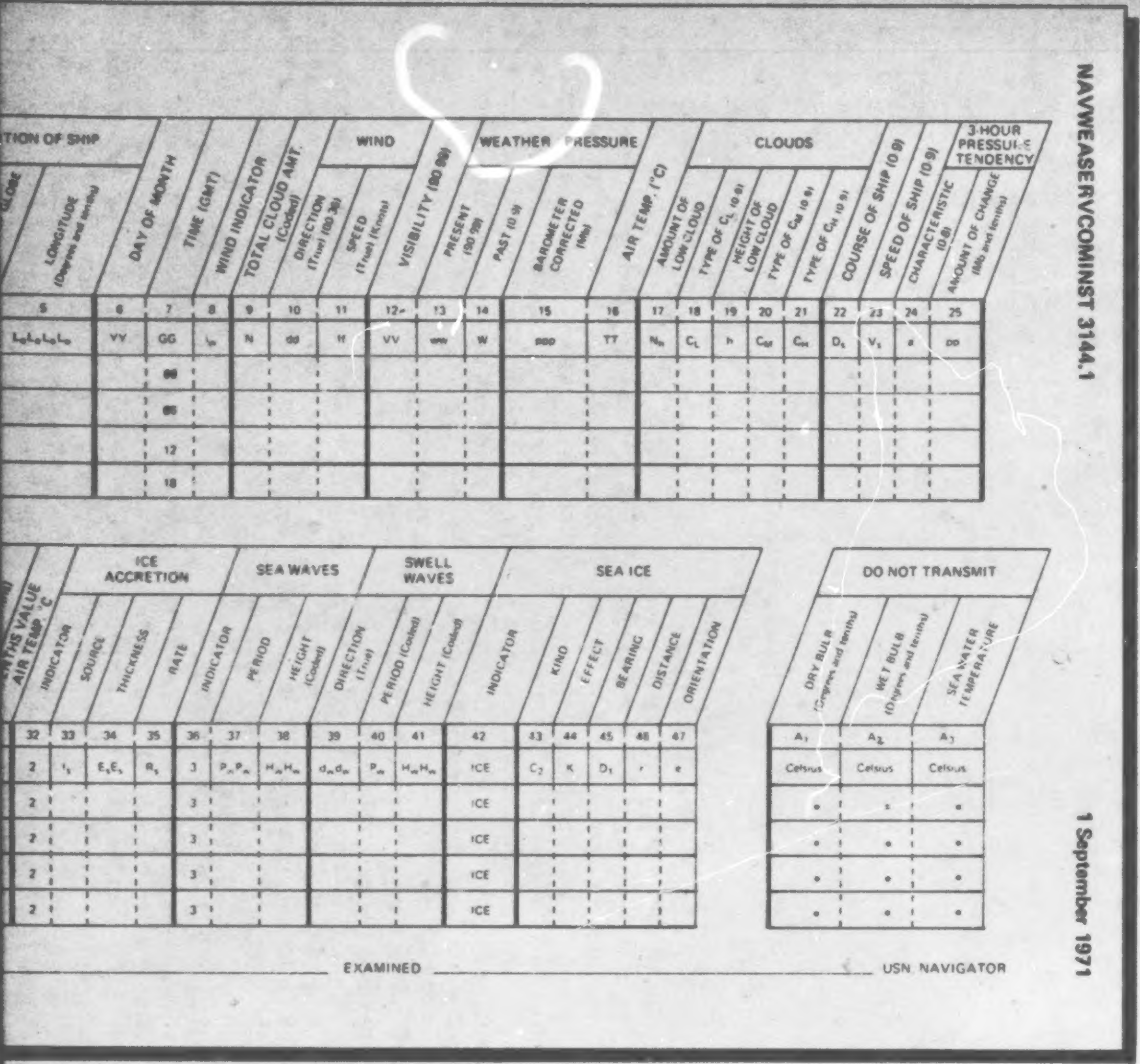
POSITION OF SHIP									WIND			WEATHER PRESSURE				CLOUDS							3-HOUR PRESSURE TENDENCY	
FIRST GROUP OF MESSAGE	INDICATOR	LATITUDE (Degrees and tenths)	QUARTER OF GLOBE	LONGITUDE (Degrees and tenths)	DAY OF MONTH	TIME (GMT)	WIND INDICATOR	TOTAL CLOUD AMT. (Coded)	DIRECTION (True) (00-36)	SPEED (True) (Knots)	VISIBILITY (90-99)	PRESENT (00-99)	PAST (0-9)	BAROMETER CORRECTED (Mb)	AIR TEMP. (°C)	AMOUNT OF LOW CLOUD	TYPE OF C_L (0-9)	HEIGHT OF LOW CLOUD	TYPE OF C_M (0-9)	TYPE OF C_H (0-9)	COURSE OF SHIP (0-9)	SPEED OF SHIP (0-9)	CHARACTERISTIC (0-8)	AMOUNT OF CHANGE (Mb and tenths)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
IRCS	99	$L_aL_aL_a$	Q_c	$L_oL_oL_oL_o$	YY	GG	i_w	N	dd	ff	VV	ww	W	ppp	TT	N_h	C_L	h	C_M	C_H	D_s	V_s	a	pp
	99					00																		
	99					06																		
	99					12																		
	99					18																		

						ICE ACCRETION				SEA WAVES			SWELL WAVES			SEA ICE					
INDICATOR	AIR SEA DIFF. (Coded)	DEW POINT (°C)	INDICATOR	SEA WATER TEMPERATURE (Degrees and tenths)	TENTHS VALUE AIR TEMP. °C	INDICATOR	SOURCE	THICKNESS	RATE	INDICATOR	PERIOD	HEIGHT (Coded)	DIRECTION (True)	PERIOD (Coded)	HEIGHT (Coded)	INDICATOR	KIND	EFFECT	BEARING	DISTANCE	ORIENTATION
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
0	T_sT_s	T_dT_d	1	$T_wT_wT_w$	t_T	2	I_s	E_sE_s	R_s	3	P_wP_w	H_wH_w	d_wd_w	P_w	H_wH_w	ICE	C_2	K	D_1	r	e
0			1			2				3						ICE					
0			1			2				3						ICE					
0			1			2				3						ICE					
0			1			2				3						ICE					

DO NOT TRANSMIT		
DRY BULB (Degrees and tenths)	WET BULB (Degrees and tenths)	SEA WATER TEMPERATURE
A_1	A_2	A_3
Celsius	Celsius	Celsius
•	•	•
•	•	•
•	•	•
•	•	•

REMARKS ______________________ EXAMINED ______________________ USN. NAVIGATOR

Figure 14-15.—Department of the Navy Ship Weather Observation Sheet continued).



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TION OF SHIP						WIND			WEATHER		PRESSURE			CLOUDS							3-HOUR PRESSURE TENDENCY	
LOBE	LONGITUDE (Degrees and tenths)	DAY OF MONTH	TIME (GMT)	WIND INDICATOR	TOTAL CLOUD AMT. (Coded)	DIRECTION (True) (00-36)	SPEED (True) (Knots)	VISIBILITY (90-99)	PRESENT (00-99)	PAST (0-9)	BAROMETER CORRECTED (Mb)	AIR TEMP. (°C)	AMOUNT OF LOW CLOUD	TYPE OF C_L (0-9)	HEIGHT OF LOW CLOUD	TYPE OF C_M (0-9)	TYPE OF C_H (0-9)	COURSE OF SHIP (0-9)	SPEED OF SHIP (0-9)	CHARACTERISTIC (0-8)	AMOUNT OF CHANGE (Mb and tenths)
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	$L_oL_oL_oL_o$	YY	GG	i_w	N	dd	ff	VV	ww	W	ppp	TT	N_h	C_L	h	C_M	C_H	D_s	V_s	a	pp
			00																		
			06																		
			12																		
			18																		

		ICE ACCRETION			SEA WAVES			SWELL WAVES			SEA ICE					
NTHS VALUE AIR TEMP °C	INDICATOR	SOURCE	THICKNESS	RATE	INDICATOR	PERIOD	HEIGHT (Coded)	DIRECTION (True)	PERIOD (Coded)	HEIGHT (Coded)	INDICATOR	KIND	EFFECT	BEARING	DISTANCE	ORIENTATION
	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
	2	I_s	E_sE_s	R_s	3	P_wP_w	H_wH_w	d_wd_w	P_w	H_wH_w	ICE	c_2	K	D_i	r	e
	2				3						ICE					
	2				3						ICE					
	2				3						ICE					
	2				3						ICE					

DO NOT TRANSMIT		
DRY BULB (Degrees and tenths)	WET BULB (Degrees and tenths)	SEA WATER TEMPERATURE
A_1	A_2	A_3
Celsius	Celsius	Celsius
.	.	.
.	.	.
.	.	.
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re 14-15.—Department of the Navy Ship Weather Observation Sheet continued).

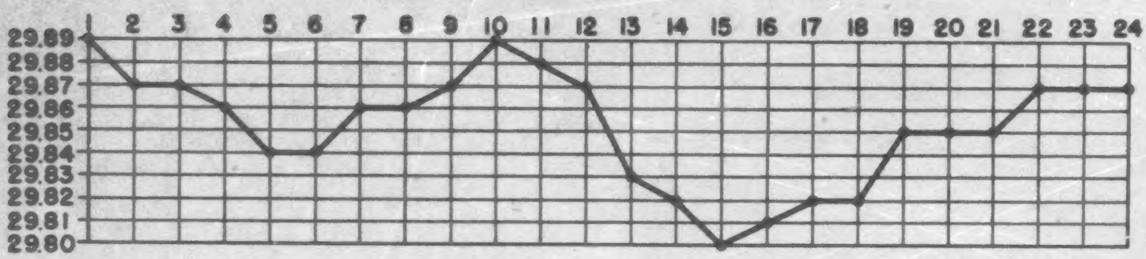

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Figure 14-16.—Hourly pressure readings showing diurnal change.

surface. Because of the changing pressure, quite a mass of figures on pressure accumulates in your deck log. It's difficult to base a prediction on these long lists of numbers. But with a simple graph, such as that in figure 14-16, you have a pictorial view of the daily pressure change.

If you take the graphs for successive days, you can tell, by comparing the pressure for the same hours on different days, whether the trend is toward higher or lower pressure. Another indication of the approach of a low-pressure area is a continuous lowering or pressure at the time of day when you know it should be rising.

But, assuming that you continually have observed lower readings on your barometer, do you know whether you are (1) within a high-pressure area, moving away from its center, or (2) within a low-pressure area, moving toward its center? The fact is, it doesn't matter too much. So long as you know that the pressure is going down, you are forewarned. Should you advise the OOD? Yes. Most OODs desire to be notified of changes in the barometer even if the change is not an indication of anything serious. Note in figure 14-11 that the isobars are farther apart in a high than in a low. This spacing means that the rate of change (the gradient) is gradual in the anticyclone but more abrupt in the cyclone, which may be a hint of what is happening. When the barometer needle dives sharply, you know you're in the immediate vicinity of a low, and you should notify the OOD to that effect at once. The faster the pressure drops, the more certain it is that you are headed for the center of a low or that a low is approaching your position.

WIND

As you approach the center of a low-pressure area, the winds become stronger. Both wind velocity and wind direction are significant factors. Quartermasters must be able to compute the direction and velocity of the true wind from the information at hand.

FINDING TRUE WIND

When there is no wind-measuring equipment aboard, the wind direction and speed must be obtained by other means. When the sea condition can be observed, the Beaufort scale of wind should be used to estimate the windspeed. The speed is determined by the size and character of the waves that are running with the wind. The Beaufort scale of wind appears in table 14-2. Wind direction can be obtained by observing the direction from which ripples and small wavelets are coming because they run with the wind. The direction of the wind may also be determined by taking a bearing on wind "streaks" if the wind is strong enough to produce these streaks. This procedure either gives the direction of the true wind or its reciprocal. Wind streaks are readily observed for windspeeds in excess of 20 knots, and experienced observers can distinguish wind streaks with windspeeds as low as 12 knots. When the true wind direction cannot be obtained in this manner, you should use the procedure described next.

Table 14-2.—Beaufort Wind Scale and Correlative Sea Disturbance Scale

Beaufort No.	Knots	Descriptive terms	Sea criterion 1939 (provisional)	Approx. equivalent sea disturbance scale in open sea		
				Code Fig.	Description	Mean ht. of waves in feet
0	Less than 1	Calm	Sea like a mirror	0	Calm (glassy).	....
1	1-3	Light air	Ripples with the appearance of scales are formed but without foam crests.	1	Calm (rippled)	1/2
2	4-6	Light breeze	Small wavelets, still short but more pronounced, crests have a glassy appearance and do not break	1	....	1
3	7-10	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered whitecaps.	2	Smooth (wavelets)	2-1/2
4	11-16	Moderate breeze	Small waves, becoming longer; fairly frequent whitecaps	3	Slight	5
5	17-21	Fresh breeze	Moderate waves, taking a more pronounced long form; many whitecaps are formed (chance of some spray).	4	Moderate.	9
6	22-27	Strong breeze	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray)	5	Rough	14
7	28-33	Moderate gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind. (Spray begins to be seen).	6	Very rough	19
8	34-40	Fresh gale[1]	Moderately high waves of greater length; edges of crests break into spray. The foam is blown in well-marked streaks along the direction of the wind.	7	High.	25
9	41-47	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Sea begins to roll. Spray may affect visibility	7	....	31

69.133

Table 14-2.—Beaufort Wind Scale and Correlative Sea Disturbance Scale, (Continued)

Beaufort No.	Knots	Descriptive terms	Sea criterion 1939 (provisional)	Approx. equivalent Sea Disturbance scale in open sea		
				Code Fig.	Description	Mean ht. of waves in feet
10	48-55	Whole gale .	Very high waves with long overhanging crests. The resulting foam in great patches is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes a white appearance. The rolling of the sea becomes heavy and shocklike. Visibility is affected .	8	Very high .	37
11	56-63	Storm .	Exceptionally high waves. (Small- and medium-sized ships might be for a long time lost to view behind the waves.) The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown in froth. Visibility affected.	9	Phenomenal	45 or more
12	Above 64 . .	Hurricane .	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.	9	. . . .	. . . .

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When the surface of the sea cannot be observed, the true wind can be determined from the apparent wind as follows:

1. By observing the effects of the wind on the ship's flag, smoke, or rigging, estimate the apparent wind direction to the nearest 10° off the bow of the ship, and apparent windspeed to the nearest 5 knots. (See table 14-3.) If the ship has an anemometer, the speed and direction of the apparent wind may be determined from it.
2. Using the ship's course and speed and apparent wind direction and speed, find the true wind by the maneuvering board method.

An anemometer (figure 14-17), is an instrument fixed somewhere aloft—usually at the masthead. The wind blows into metal cups attached to the ends of arms. The whirling cups revolve a spindle, communicating with a synchro repeater on a pilothouse or charthouse bulkhead. Figure 14-18 shows one type of synchro repeater.

The upper dial of the repeater is graduated in 10° intervals and shows the apparent relative direction from which the wind is blowing. In this illustration the direction is about 287°.

The lower dial indicates the apparent windspeed (true windspeed when the ship is

Table 14-3.–Apparent Windspeed

Speed (knots)	Indication
Less than 1	Calm; smoke rises vertically.
1-3	Smoke drifts from funnel.
4-6	Wind felt on face.
7-10	Wind extends light flag.
11-16	Wind raises dust, cinders, loose paper, and the like.
17-21	Wind waves and snaps flags briskly.
22-27	Whistling in rigging.
28-33	Inconvenience felt walking against wind.
34-40	Generally impedes progress.

69.134

stationary). The windspeed dial in the illustration shows about 87 knots. This reading means that the force exerted by 87 knots of wind is whirling the anemometer cups. This apparent force and direction of wind is the result of the true wind combined with the movement of the ship and is, therefore, called resultant wind.

The general accuracy of a computed wind problem may be checked easily by means of the rules given here. If the solution to a wind problem violates any of these rules, the solution is wrong and should be reworked.

1. The true direction of the wind is always on the same side of the ship as the apparent direction, but farther from the bow than the apparent direction.
2. The true speed of the wind is greater than the apparent speed whenever the apparent direction is abaft the beam.
3. The true speed of the wind is the same as (or less than) the apparent speed whenever the true direction is forward of the beam.

True windspeed and direction may be determined by using a maneuvering board. That method of determining true wind is explained in chapter 15 of this book.

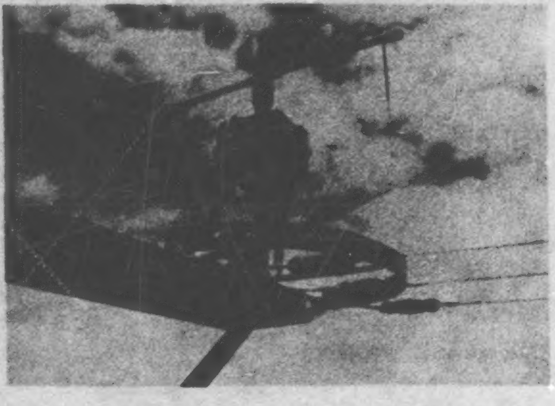

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Figure 14-17.–Anemometer.

The true wind may be computed using the True Wind Computer, CP-264/U. The computer is a simple plastic device with instructions printed on its reverse side. The computer method is as accurate as the maneuvering board method and it solves true wind problems much faster.

CLOUDS

The atmosphere always contains–in greater or smaller amounts–tiny particles, such as dust from roads, desert sand, plant pollen, salt particles from oceans, and factory smoke. These fragments are hygroscopic nuclei–the term means "particles that readily absorb moisture." A cloud is merely a mass of hygroscopic nuclei that have soaked up moisture from the air.

The heat generated by the Sun's energy causes earthbound moisture to evaporate (turn into water vapor). Water vapor is one of the gases that make up the atmosphere. Water vapor is lighter than air, thus it rises. If the air it passes into is cold enough, the vapor condenses, that is, it turns back into moisture. The water droplets that result from this process cling to the hygroscopic nuclei. Many of these water-soaked nuclei bunched together form a cloud. Fog is the same in principle, but it's a cloud on the ground.

Changes in atmospheric conditions account for the many different shapes of clouds and for

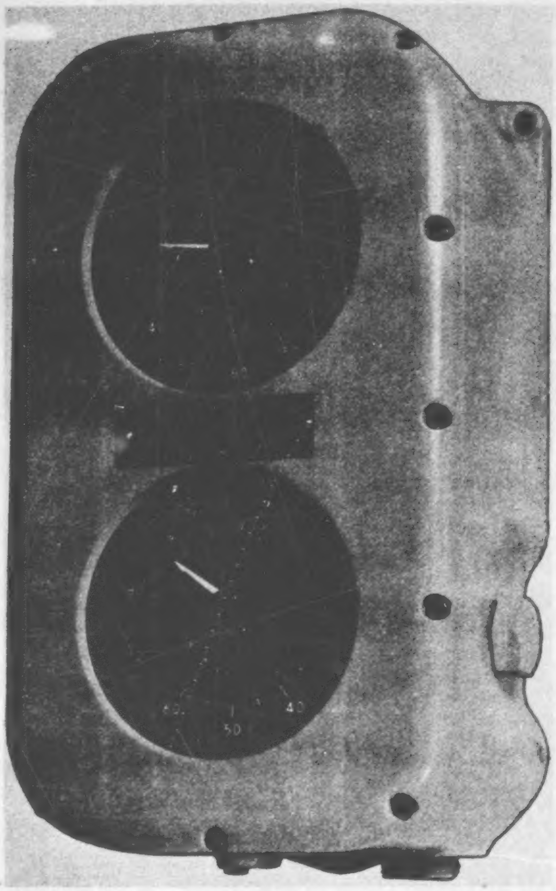

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Figure 14-18.—Synchro repeater showing apparent wind velocity and direction.

their presence at various altitudes. Formations of the clouds give a clue concerning the existing forces at play in the atmosphere. That's why you must keep an accurate record of clouds in the deck log.

CIRRUS (CI)

Cirrus clouds (figure 14-19) are detached clouds of delicate and stringy appearance, generally white in color, without shading. They appear in the most varied forms, such as isolated tufts, lines drawn across the sky, branching featherlike plumes, and curved lines ending in tufts.

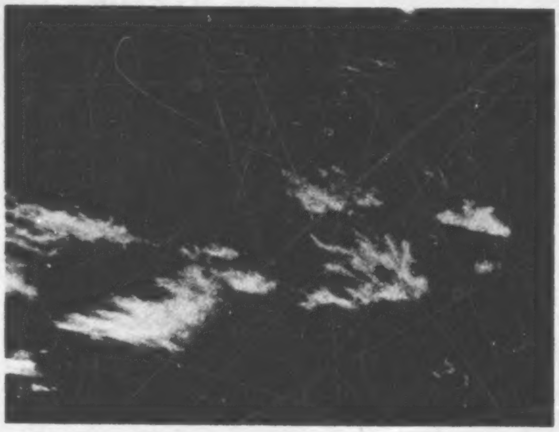

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Figure 14-19.—Cirrus.

Cirrus clouds are composed of ice crystals, hence their transparent character depends upon the degree of separation of the crystals. Before sunrise and after sunset, cirrus clouds may still be colored bright yellow or red. Being high-altitude clouds, they light up before lower clouds and fade out much later. Cirrus clouds often indicate the direction in which a storm may lie.

CIRROCUMULUS (CC)

Cirrocumulus clouds (figure 14-20), commonly called "mackerel sky," look like rippled sand, or like cirrus clouds containing globular masses of cotton, usually without shadows. Cirrocumulus clouds are an indication that a storm probably is approaching.

CIRROSTRATUS (CS)

Cirrostratus clouds (figure 14-21) are a thin whitish veil which does not blur the outlines of the Sun or Moon, but gives rise to halos (colored or whitish rings and arcs around the Sun or Moon; the colored arcs apear reddish on the inside edges.) A milky veil of fog (thin stratus)

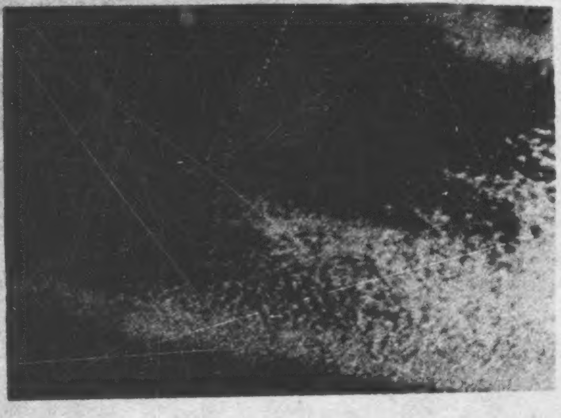

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Figure 14-20—"Mackerel sky" cirrocumulus.

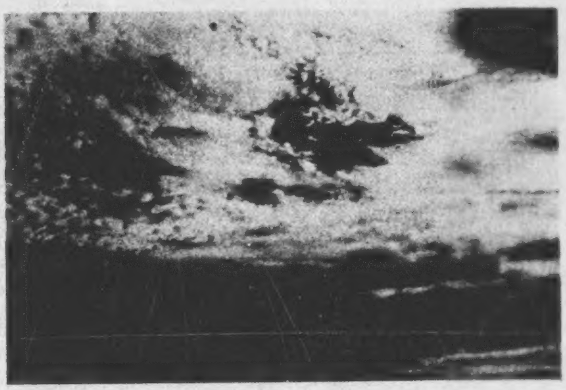

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Figure 14-22.—Altocumulus.

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Figure 14-21.—Cirrostratus.

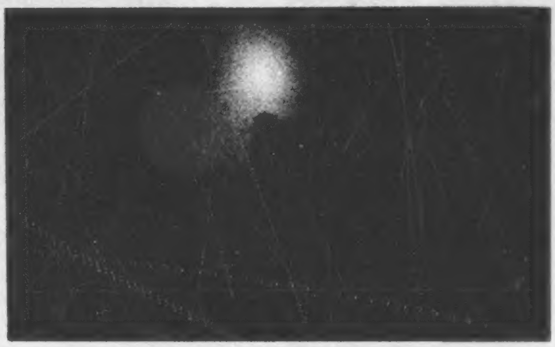

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Figure 14-23.—Altostratus.

and altostratus are distinguished from a veil or cirrostratus of similar appearance by the halo phenomenon, which the Sun or Moon nearly always produces in a layer of cirrostratus. The appearance of cirrostratus is a good indication of rain.

ALTOCUMULUS (AC)

Altocumulus clouds (figure 14-22) are a layer (or patches) composed of flattened globular masses, the smallest elements of the regularly arranged layer being fairly small and thin, with or without shading. The balls or patches usually are arranged in groups, in lines, or in waves. Sometimes a corona (similar to a halo but with the reddish color on the outside edges) may be seen on the altocumulus. This cloud form differs from the cirrocumulus by generally having larger masses, by casting shadows, and by having no connection with the cirrus forms. When followed by cirrocumulus, a thunderstorm is nearing.

ALTOSTRATUS (AS)

Looking like a thick cirrostratus, but without halo phenomena, the altostratus (figure 14-23) is a fibrous veil or sheet, gray or bluish in color. Sometimes the Sun or Moon is obscured completely. At other times they can be vaguely seen, as through ground glass. Light rain or heavy snow may fall from a cloud layer that is definitely altostratus.

NIMBOSTRATUS (NS)

Nimbostratus clouds (figure 14-24) are a dark gray colored amorphous (shapeless) and rainy layer of cloud. They usually are nearly uniform and feebly illuminated, seemingly from within.

When precipitation occurs, it is in the form of continuous rain or snow, but nimbostratus may occur without rain or snow. Often there is precipitation that does not reach the ground; in which cases, the base of the cloud usually looks wet because of the trailing precipitation.

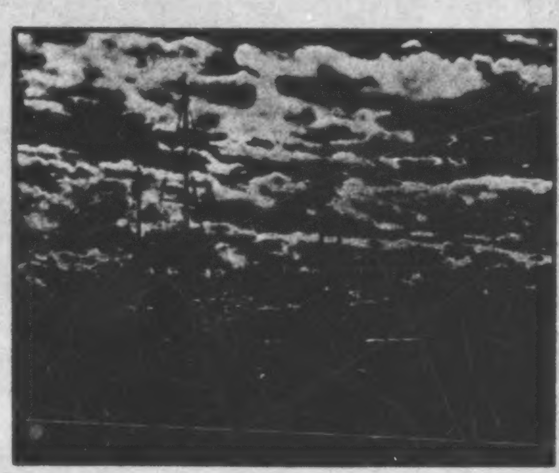
In most instances the nimbostratus evolves from an altostratus, which grows thicker and whose base becomes lower until it becomes a layer of nimbostratus. When precipitation falls continually, the base of the cloud may extend into the low cloud family range.

STRATOCUMULUS (SC)

Stratocumulus clouds (figure 14-25) are a layer (or patches) of clouds composed of globular masses or rolls. The smallest of the regularly arranged elements are fairly large. They are soft and gray, with dark spots.

69.103

Figure 14-24.—Nimbostratus.



69.183

Figure 14-25.—Stratocumulus.

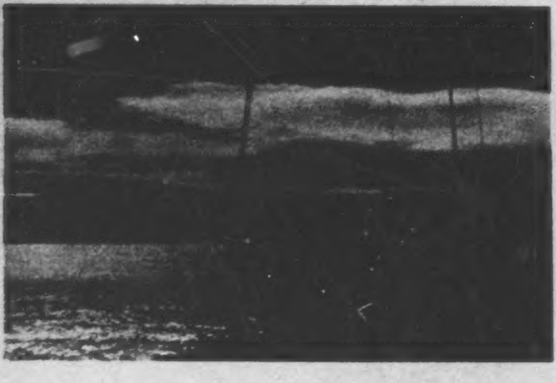
Underneath stratocumulus waves or rolls, strong winds occur. Under the thick parts strong up-currents rise. Above the cloud layer the air is smooth, but it is turbulent below and within the layer.

STRATUS (ST)

Stratus clouds (figure 14-26) are a low, uniform layer of clouds, resembling fog, but not resting on the ground. A veil of stratus gives the sky a hazy appearance. Usually, only drizzle is associated with stratus. When there is no precipitation, the stratus cloud form appears drier than other similar forms, and it shows some contrasts and some lighter transparent parts.

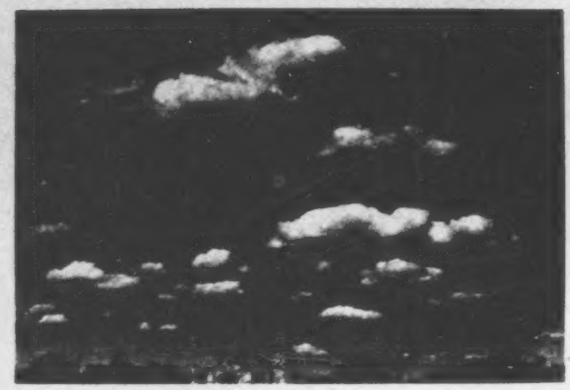
CUMULUS (CU)

Cumulus clouds (figure 14-27) are dense clouds with vertical development. Their upper surfaces are dome-shaped and exhibit rounded projections, and their bases are nearly horizontal. Stratocumulus clouds resemble ragged cumulus clouds in which the different parts show constant change.



69.102

Figure 14-26.–Stratus.



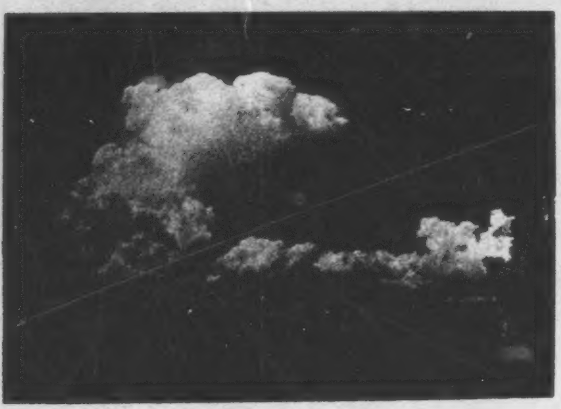
69.111

Figure 14-27.–Cumulus.

Strong updrafts exist under and within all cumulus formations. In fact, cumulus clouds, like other forms of vertically developed clouds, are caused by updrafts.

CUMULONIMBUS (CB)

Cumulonimbus clouds (figure 14-28) are heavy masses of cloud, with towering vertical development, whose cumuliform summits resemble mountains or towers. Their upper parts have a fibrous texture, and often they spread out in the shape of an anvil.



69.112

Figure 14-28.–Cumulonimbus.

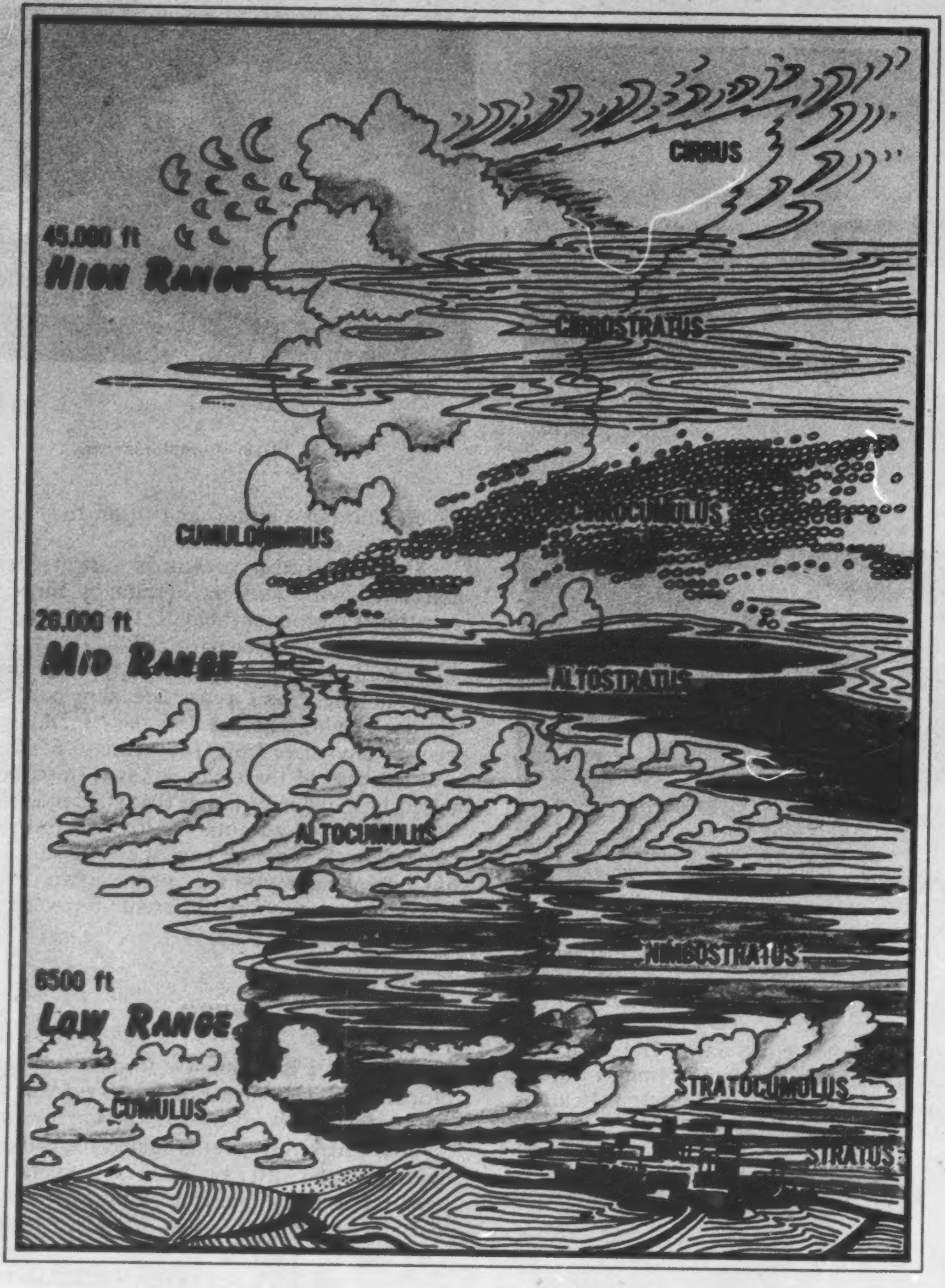
Cumulonimbus clouds are generally associated with showers of rain or snow, and sometimes produce hail. They often are associated with thunderstorms.

Figure 14-29 is a view of all types of clouds. Most of the cloud types are shown at their average height. The bases of the cumulonimbus may be anywhere from 1600 feet to 6500 feet, and the base of these clouds has been purposely raised in the illustration so that all clouds can be shown to better advantage. Although you would never see all types at any one time in nature, quite frequently you may observe two or three layers of clouds of different types at one observation.

FOG

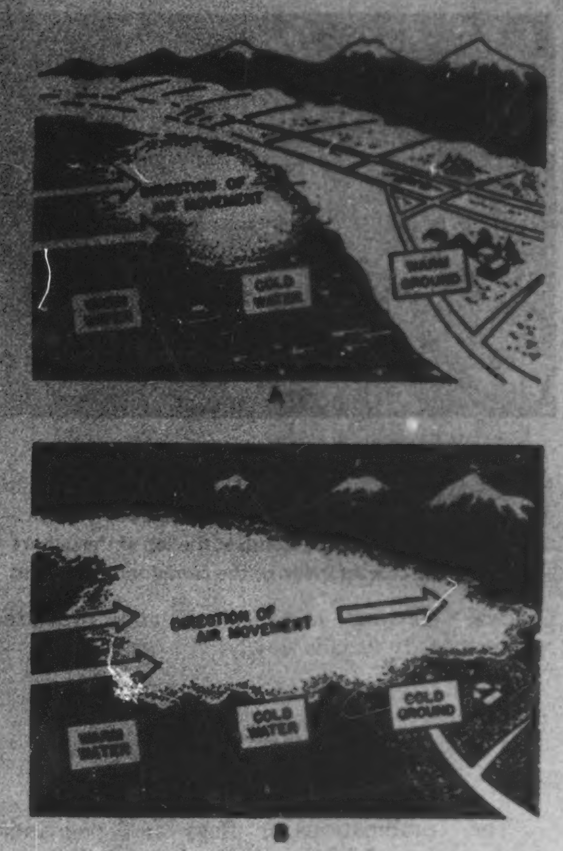
Fog at sea is frequently formed through the process known as advection (moving forward). If warm air that passed over warm water moves to an area where the water is colder, fog is likely to develop in the latter region. The temperature of seawater is fairly uniform within a large area which accounts for fog that often lasts for many days and nights at sea.

The great fog banks of the North Atlantic, as well as those around the Aleutians, demonstrate what can happen when two adjacent bodies of


CIRRUS
45,000 ft
HIGH RANGE
CIRROSTRATUS
CIRROCUMULUS
CUMULONIMBUS
20,000 ft
MID RANGE
ALTOSTRATUS
ALTOCUMULUS
NIMBOSTRATUS
6500 ft
LOW RANGE
STRATOCUMULUS
CUMULUS
STRATUS

69.101

Figure 14-29.—The ten cloud genera.

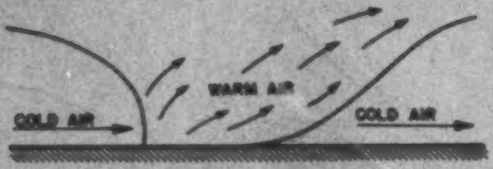


69.113

Figure 14-30.—How coastal (advection) fog forms and how it is dissipated (a) by day when the ground is warm, and (b) by night when the ground is cold.

water have markedly different temperatures. In the vicinity of Newfoundland, warm air that has passed over the warm Gulf Stream quickly turns to fog when it strikes the inshore current of very cold water that flows southward along the coastline. Off Alaska, the same situation prevails when the air from over the warm Japanese stream (Kuroshio) comes in contact with the cold southward-flowing waters of the Bering Sea (Oyashio).

Figure 14-30 gives you an idea of the mechanisms of fog formation. Along coastlines there are special conditions. Onshore winds blow warm, moist air inland from the ocean. The waters adjacent to the coast are usually colder than those farther offshore. So, as you can see in figure 14-30, at night an onshore wind lays down a thick blanket of fog that often extends some distance inland. The fog hangs on until the Sun heats up the land enough to evaporate the droplets or until an offshore wind drives the fog blanket away.



69.114

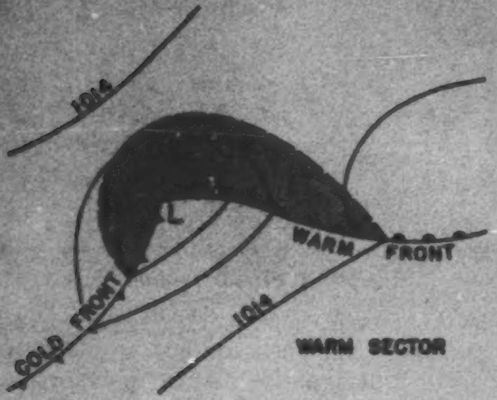
Figure 14-31.—The cold front part and the warm front part of a frontal system.

How can you tell when a fog is on the way or in the process of formation? The difference between the temperature shown by the wet bulb and the dry bulb of the psychrometer, called wet-bulb depression, is your fog indicator. In general, fog forms when the depression is 4° or less. A continuous record of the wet-bulb depression serves as a fairly reliable predictor of fog.

FRONTS

Fronts are weather systems that are sometimes called waves. Along the front, two air masses of widely different characteristics fight a battle for supremacy. Usually the colder of the two masses, being heavier, predominates, forcing the warm air upward. Cold air behind a cold front displaces the warm air ahead of it upward (figure 14-31). The warm air behind a warm front moves upward over a retreating cold air mass. When a cold front moves faster than the warm front, it overtakes the warm front, forcing the warmest air masses upward. When these fronts converge, the remaining front on the surface is called an occluded front.

A cold front or a warm front may extend for hundreds of miles long, but the area in which frontal weather disturbances take place is usually a band 15 to 50 miles wide for a cold front and up to 300 miles for a warm front. The point



69.115

Figure 14-32.—A frontal system sketched on a weather chart.

where the cold and the warm fronts converge is frequently the center of a low-pressure area.

Figure 14-32 shows how a frontal system is sketched on a weather chart. The figures along the isobars are millibars of pressure. Compare the pressure of 1008 mb around the low with that of 1016 mb within the warm sector.

When a cold front is coming your way, the first change you notice is darkening of the horizon to the west and to the north. (See figure 14-33.) Very soon the cloud ceiling lowers and rain begins. A fast-moving cold front (which can move 720 miles in a day), with typical cumulonimbus clouds preceding it, brings sudden violent showers or thunderstorms. If the cold front is not preceded by cumulonimbus clouds, the rainfall is steady. Passage of the cold front is usually marked by a wind shift, a drop in temperature, a rise in pressure, and a rapid clearing of the sky condition and visibility.

A warm front, heralded by cirrus clouds, is followed (in order) by cirrostratus, altostratus, then nimbostratus and possibly stratus clouds. Visibility is poor in advance of a warm front; frequently fog forms and steady rain or drizzle prevails. Thunderstorms may develop ahead of this front. The frontal line is passing when a marked shift occurs in the wind direction, and the temperature of the atmosphere rises sharply.

69.116

Figure 14-33.—A cold front seen from the air. The anvil-like appearance of the clouds at the top of the picture is another characteristic of the cumulonimbus types.

Gradual clearing takes place and pressure remains steady or falls slowly.

UNITED STATES STORM-WARNING SIGNALS

The combinations of flags and pennants shown in figure 14-34 are hoisted at the National Weather Service and other shore stations in the United States to indicate the presence or future presence of unfavorable winds. The meanings of the various displays are given below.

Small craft warning: One red pennant displayed by day and a red light over a white light at night indicate that winds up to 38 miles an hour (33 knots) and/or sea conditions dangerous to small craft operations are forecast for the area.

Gale warning: Two red pennants displayed by day and a white light above a red light at night indicate that winds ranging from 39 to 54 miles an hour (34 to 47 knots) are forecast for the area.

Storm warning: A single square red flag with a black center displayed during daytime and two

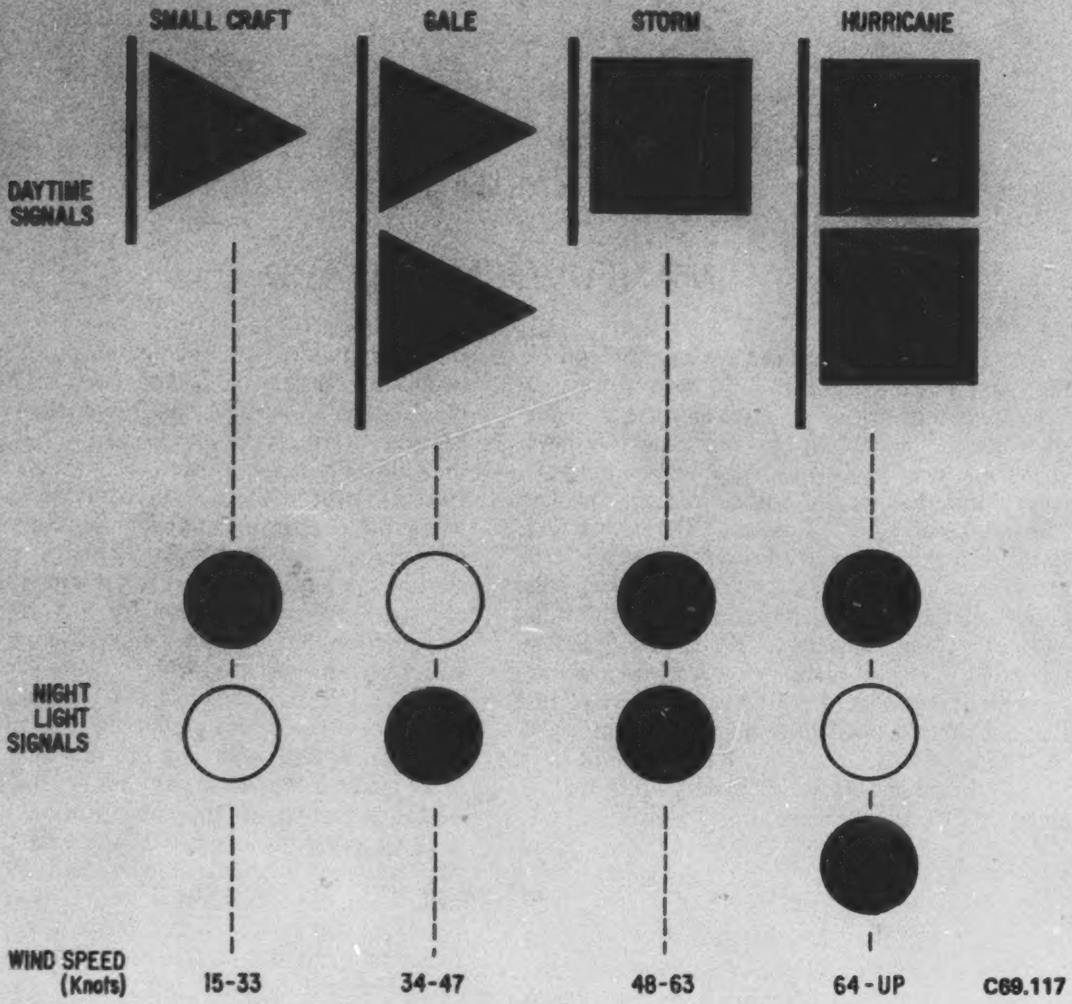

SMALL CRAFT
GALE
STORM
HURRICANE
DAYTIME SIGNALS
NIGHT LIGHT SIGNALS
WIND SPEED (Knots)
15-33
34-47
48-63
64-UP
C69.117

Figure 14-34.—Small craft, gale, storm, and hurricane warnings.

red lights at night indicate that winds 55 miles an hour (48 knots) and above, no matter how high the speed, are forecast for the area. If the winds are associated with a tropical cyclone (hurricane), the storm-warning display indicates that winds within the range 55 to 73 miles an hour (48 to 63 knots) are forecast.

Hurricane warning (displayed only in connection with a tropical cyclone, hurricane): Two square red flags with black centers displayed by day and a white light between two red lights at night indicate that winds 74 miles an hour (64 knots) and above are forecast for the area.

CHAPTER 15

MANEUVERING BOARD

As a Quartermaster you have already learned that you must keep a ship in safe water and navigate her from one point to another by using all available means. Up to this point we have primarily discussed only true (geographical) movement; that is, the motion of ship through the water and over the ground. The course and speed of a ship through the water represents its movement over the ground (disregarding the effect on the ship of such variables as the tide, current, and wind). This is called actual (geographical) movement. However, even actual movement is relative because it is relative to the Earth's surface, which is a moving body. All motion is relative to some reference and it is very important when discussing motion to clearly define the reference point used.

RELATIVE MOTION

Relative motion is defined as the apparent movement that takes place between two objects when one or both are moving independently.

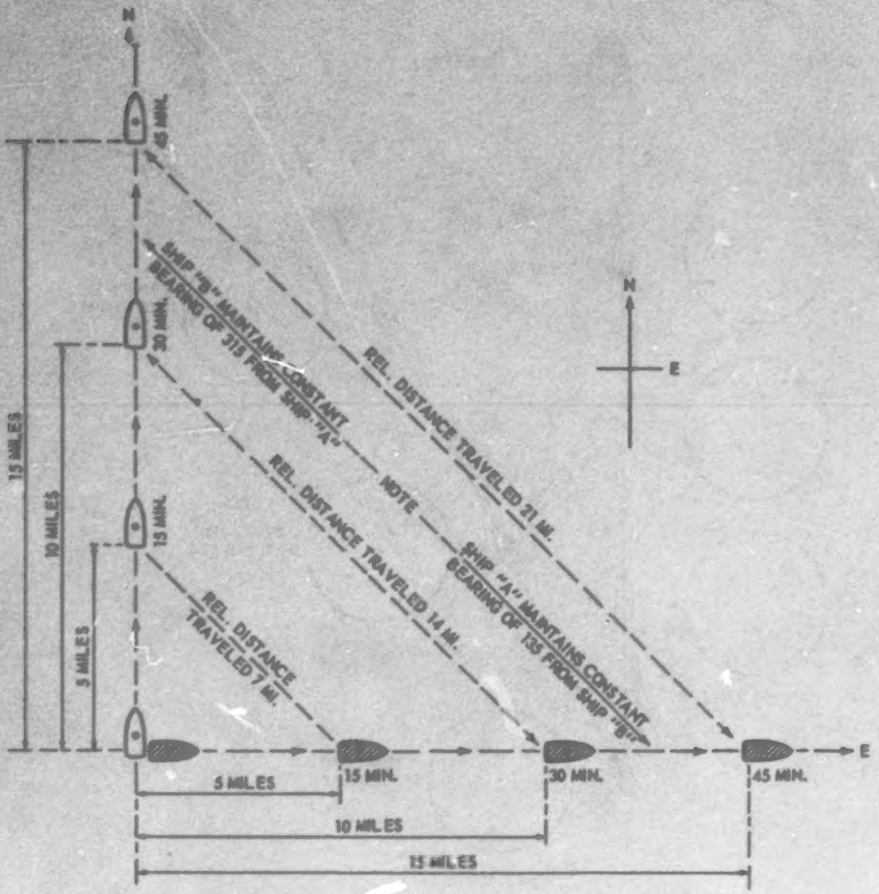
For a practical application of relative motion at work, think of it this way: (1) as you stroll along a sidewalk, an understanding of relative motion prevents you from colliding with other pedestrians; (2) when you are driving an automobile, a comprehension of relative motion prevents you from running into other cars; and (3) as you play ball, this knowledge enables you to determine at which point to intercept the ball in order to catch it.

Let us consider a few examples of relative motion in everyday life. These examples are included to explain why relative motion is defined as apparent movement.

Driving along a street in a car, you notice a lamppost on the right-hand curb in the next block. As you approach that point, the lamppost changes bearing very slowly to the right. Upon drawing nearer, the motion to the right tends to increase until you are even with the lamppost, when the lamppost disappears behind your line of vision. The lamppost actually remained stationary; but, in relation to your movement, it appeared to have motion to the right. The foregoing is an example of relative movement with only one object moving.

Now, let us focus on two moving objects under circumstances similar to the preceding example. Assume that you are driving down the same street in the same automobile. But, instead of the lamppost on the curb, you see a person walking along the sidewalk in the same direction that you are headed. As you drive along, the pedestrian changes bearing very slowly to the right. As you continue, this motion to the right increases until the person moves far enough to the right and behind your line of vision. The RELATIVE MOTION of the person walking was opposite to your direction of movement because of your greater speed, but the TRUE DIRECTION of motion of the person walking was the same as yours.

The concept of relative movement is illustrated in figure 15-1 in which two ships leave the same anchorage, one sailing north and the other sailing east. If each ship makes 20 knots, each will travel 5 nautical miles in the first 15 minutes. At that time, the ships will be approximately 7 miles apart. The ship sailing east will now be southeast of the other ship. The movement that has taken place between them—leaving the same spot and being approximately 7 miles apart after 15 minutes—is


N
45 MIN.
30 MIN.
15 MIN.
15 MILES
10 MILES
5 MILES
SHIP "B" MAINTAINS CONSTANT BEARING OF 315 FROM SHIP "A"
NOTE
SHIP "A" MAINTAINS CONSTANT BEARING OF 135 FROM SHIP "B"
REL. DISTANCE TRAVELED 21 MI.
REL. DISTANCE TRAVELED 14 MI.
REL. DISTANCE TRAVELED 7 MI.
N
E
E
15 MIN.
30 MIN.
45 MIN.
5 MILES
10 MILES
15 MILES

58.89

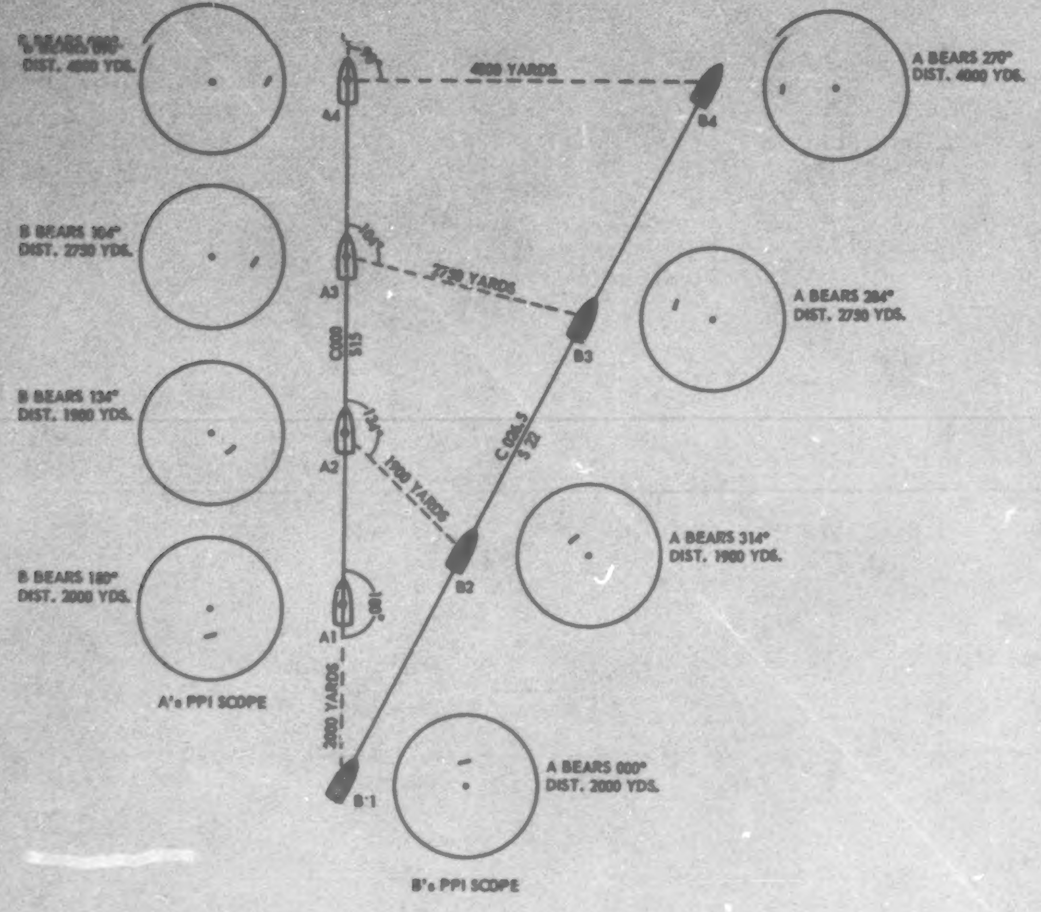
Figure 15-1.—Relative movement.

different from the geographical movement of either ship. It is the result of both their geographical movements measured relative to the other.

If both ships follow their respective routes for another 15 minutes, each will have travelled 10 nautical miles from the starting point and they will be separated by approximately 14 miles. After 45 minutes, they will be separated by approximately 21 miles, although each will have sailed only 15 miles. Each ship, so far as the other is concerned, is moving about 7 miles farther every 15 minutes, but always on the same relative bearing. Thus, in addition to the motion of the individual ships—one to the north and the other to the east—there is also a motion existing between the two in a southeast-northwest direction. This motion is the relative movement between them.

RELATIVE PLOT

A relative plot is a drawing to scale showing the position of one moving object relative to other objects. Since we are interested in the movement of one ship relative to another, we can represent relative motion directly if we


B BEARS 090°
DIST. 4000 YDS.
B BEARS 104°
DIST. 2750 YDS.
B BEARS 134°
DIST. 1900 YDS.
B BEARS 180°
DIST. 2000 YDS.
A's PPI SCOPE
4000 YARDS
2750 YARDS
1900 YARDS
2000 YARDS
104°
134°
180°
A4
A3
A2
A1
C000
S15
C 026.5
S 22
B4
B3
B2
B1
A BEARS 270°
DIST. 4000 YDS.
A BEARS 284°
DIST. 2750 YDS.
A BEARS 314°
DIST. 1900 YDS.
A BEARS 000°
DIST. 2000 YDS.
B's PPI SCOPE

58.91

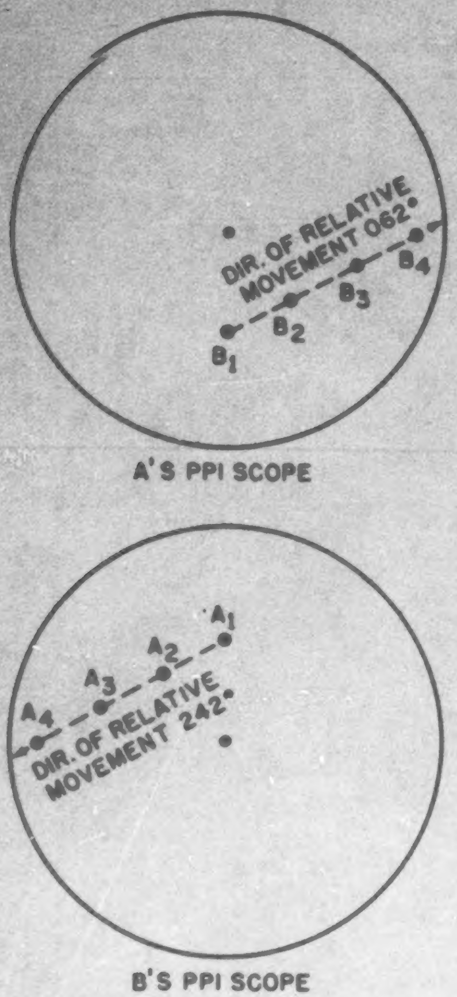
Figure 15-2.—Relative movement on a navigational plot.

select one ship as the reference ship and plot the other ship's position by using bearing and distance from the reference ship at set time intervals. These plots are termed relative positions.

The fixed ship, termed reference ship, is placed at the center of the diagram and is normally labeled R. Because plotters are interested chiefly in the position of other ships with respect to own ship, it is usually preferable to designate own ship as reference ship. If in formation, however, and maneuvering with respect to the guide ship, the guide should be designated as reference ship. It follows that any ship except a reference ship is shown in a different position on the plot.

Figure 15-2 shows ship A proceeding on course 000° at a speed of 15 knots, while ship B is on course 026.5° at speed 22 knots. When ship A is at A_1, ship B is at B_1; when ship A is at A_2, ship B is at B_2 and so on. The full lines represent navigational plots of these two ships. Their bearing and distance at any time can be determined directly by measurement.

In figure 15-3 various positions shown in figure 15-2 are presented on a plan position indicator (PPI) scope for each ship. Note that they form a straight line. It can be seen that


DIR. OF RELATIVE MOVEMENT 062°
B1
B2
B3
B4
A'S PPI SCOPE
A1
A2
A3
A4
DIR. OF RELATIVE MOVEMENT 242°
B'S PPI SCOPE

58.92

Figure 15-3.—Relative movement on a radar PPI scope.

although ship B is actually on course 026.5°, her movement relative to ship A is in the direction 062°. Similarly, the direction of relative movement of ship A with respect to ship B is the reciprocal of this direction, or 242°, although ship A is actually on course 000°.

The PPI scope permits visualization of relative movements, inasmuch as all positions of the target ship on the scope are relative to own ship. Hence, motion observed on the PPI scope is relative movement. True motion is seen on a PPI scope only when own ship is stationary.

MANEUVERING BOARD

The maneuvering board (MB), figure 15-4, has been designed specifically for solving problems involving relative movement between ships underway. The maneuvering board is a drawing to scale showing the position of one moving object relative to other moving objects. The center of the maneuvering board is the reference ship from which the positions of other ships are plotted. It is labeled with the capital letter R.

Maneuvering boards are printed with radial straight lines (to aid in plotting bearings and courses) and concentric circles (to aid in plotting distance and speeds).

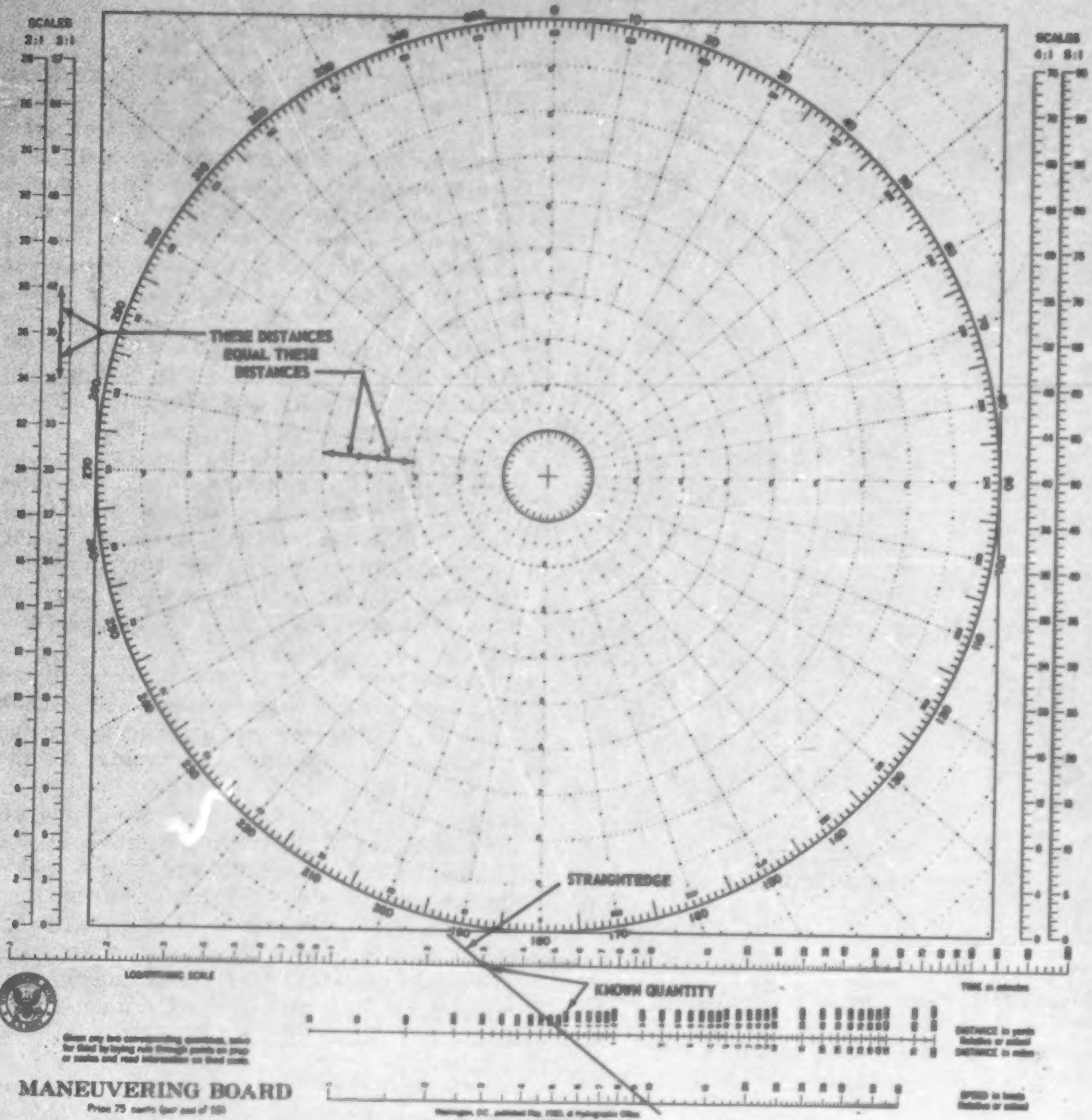
The maneuvering board has two sets of bearings printed along its outer circle. The outer numbers represent true bearings, and the inner set of numbers is printed as an aid in finding reciprocal bearings quickly. Notice in figure 15-4 that there are 10 circles. These circles represent units of distance and may be used to form a scale.

Ratio scales are provided on the left and right sides of the maneuvering board (figure 15-4) for convenience in adopting a suitable reduction for quantities pertaining to the problem at hand.

Numerical spacing on each scale is proportionate to that of the circle in the plotting area. When selecting one of these scales, the distance of each circle must be amplified accordingly. For example, when using a 1:1 scale (circle spacing in plotting area) with each circle representing 1,000 yards, the 5 circle represents 5,000 yards. If the 2:1 scale is used, the 5 circle would represent 10,000 yards (5,000 x 2).

Ordinarily, the distance between circles on the maneuvering board represents from 1,000 to 5,000 yards in the relative plot, and 1 to 5 knots in the vector diagram (discussed later). Any scale may be selected if it is adequate and convenient to include all required ranges and speeds within the 10 concentric circles on the board.

Deciding the correct range scale to use is comparatively easy. There are 5 different scales,


SCALES 2:1 3:1
SCALES 4:1 5:1
THESE DISTANCES EQUAL THESE DISTANCES
STRAIGHTEDGE
LOGARITHMIC SCALE
KNOWN QUANTITY
TIME in minutes
DISTANCE in yards
DISTANCE in miles
SPEED in knots
MANEUVERING BOARD
Price 75 cents (per pad of 50)

36.65(58)B

Figure 15-4.—Maneuvering board.

so the maximum range for these scales would be 10 (units of distance for the 1:1), 20 (units of distance for the 2:1), and so on. Thus if range to a contact is 14,000 yards, the 2:1 scale can be used because this range falls between 10,000 and 20,000 yards. The accompanying table is designed to assist in selecting range scale. If range is-

From	To	Use Scale
0 yards	10,000 yards	1:1
10,000 yards	20,000 yards	2:1
20,000 yards	30,000 yards	3:1
30,000 yards	40,000 yards	4:1
40,000 yards	50,000 yards	5:1

PLOTTING OWN SHIP IN CENTER OF MANEUVERING BOARD (MB)

With present-day accurate PPI repeaters and precise radars, a direct system of correlation between the picture on the radar repeater and the relative plot on the MB is easily accomplished by always placing own ship in the center of the maneuvering board. Since own ship is always the center of the radarscope on a PPI, the PPI can be used as a maneuvering board, and rapid and fairly accurate maneuvering solutions can be worked directly on the face of the PPI. When precise solutions are desired, the maneuvering board must be used.

Several advantages accrue from placing own ship in the center of the MB. The most important benefits are that (1) the entire plot on the maneuvering board can be seen without conversion on the PPI and (2) range and bearing of contacts can be plotted directly. Another advantage is that the relative picture drawn on the MB can be seen developing on the PPI, so that any error in plotting becomes immediately apparent as stated earlier in this chapter.

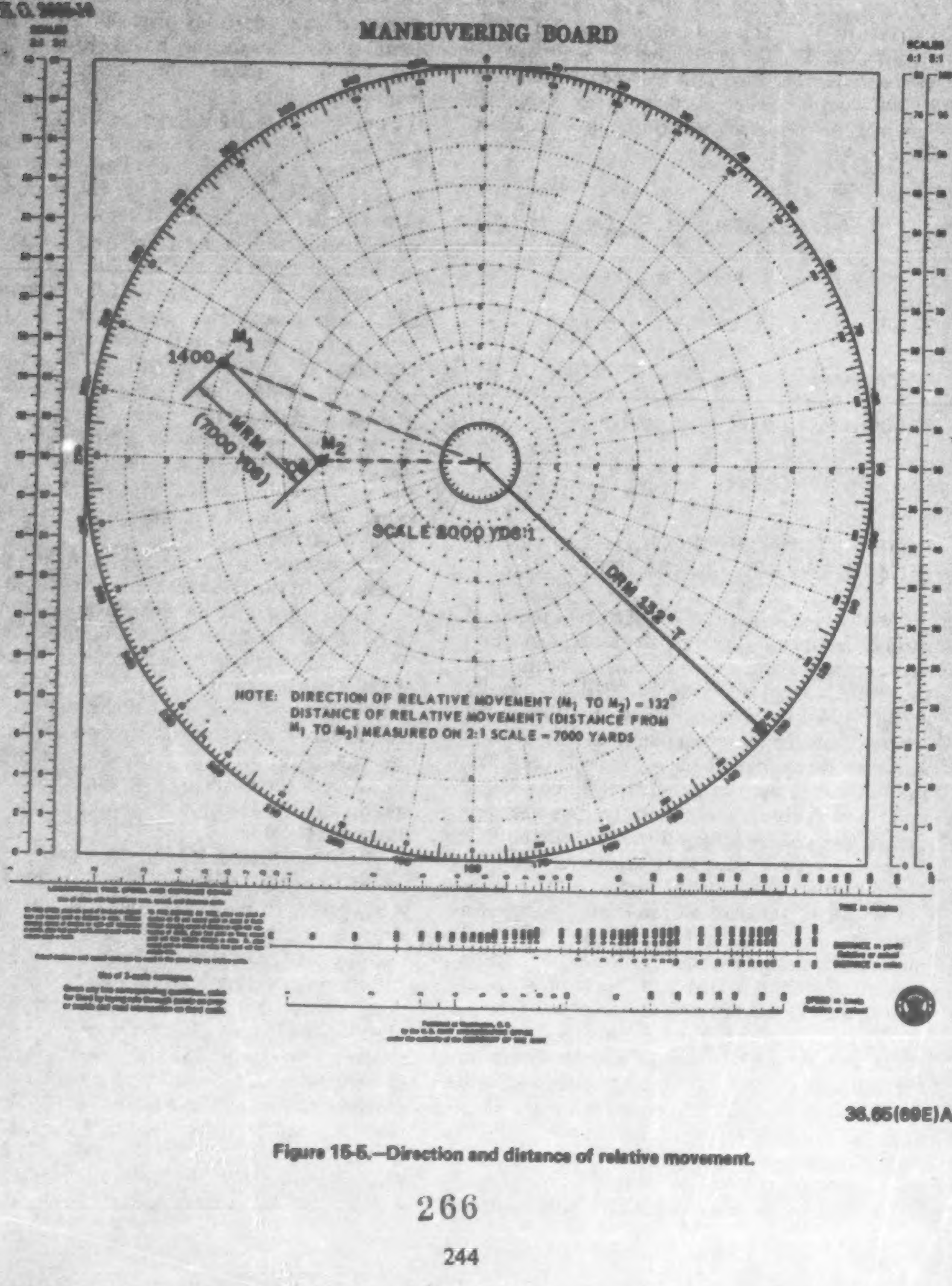
Positions of contacts in a relative plot on a maneuvering board are designated by the capital letter M (for maneuvering ship) accompanied usually by a time. Relative plots are determined by the bearing in degrees, usually true, and measured in yards from own ship or from the center of the maneuvering board (R).

The first range and bearing of the maneuvering ship is plotted and is labelled M_1; the next position (range and bearing) is plotted and labelled M_2. If more than two positions of the maneuvering ship are plotted, they are labelled M_3, M_4, M_5, etc. Relative to the reference ship (R), the plots from M_1 to M_2, etc., show the relative movement of the maneuvering ship.

The direction of the line joining the plots from M_1 to M_2, etc., represents the direction in which the maneuvering ship (target) is moving with respect to the reference ship (R). This direction is called the direction of relative movement (DRM) and is expressed as a true bearing. (See figure 15-5.) Remember, this is not a true movement; it is the relative movement, which is the result of the reference ship's course and speed and the maneuvering ship's course and speed, which makes the maneuvering ship travel down the DRM line.

The distance between the positions M_1 and M_2, measured to the same scale used to plot M_1 and M_2, is the distance the maneuvering ship (M) traveled with respect to the reference ship (R). This is called relative distance and is labelled MRM (Measurement of Relative Movement). (See figure 15-5.) Again, remember, this is not a true distance; it is the relative distance, which is the result of the reference ship's course and speed and the maneuvering ship's course and speed, which makes the maneuvering ship travel down the DRM line.

Relative distance then is the measurement of the distance, to scale, between M_1 and M_2, etc. It is important to remember that you must use the same scale used to plot M_1, M_2 etc. for this measurement. Once this measurement is made and its value determined (in miles or yards), we then introduce the element of time between plots M_1 and M_2, etc., and determine the speed of relative movement (SRM). Speed of relative movement is the speed at which the contact is moving relative to the reference ship. The SRM is determined by using the MRM for the period of time elapsed between the plots (M_1 and M_2, etc.). To solve for SRM, the nomogram at the bottom of the maneuvering board affords a


H.O. 2665-10
MANEUVERING BOARD
M_1
1400
M_2
MRM
(7000 YDS)
SCALE 2000 YDS:1
DRM 132° T

NOTE: DIRECTION OF RELATIVE MOVEMENT (M_1 TO M_2) = 132°
DISTANCE OF RELATIVE MOVEMENT (DISTANCE FROM M_1 TO M_2) MEASURED ON 2:1 SCALE = 7000 YARDS

36.65(69E)A

Figure 15-5.—Direction and distance of relative movement.

ready means of inter-converting time, speed, and distance, and solving graphically for any one of these quantities when the other two are known.

Figure 15-5 illustrates time-speed-distance scales. The top line is the time line or logarithmic scale in minutes; the middle one is the distance scale. Numbers on top of the distance scale give distance in yards; those below, distance in miles. The bottom line is the speed scale in knots.

The words "relative" or "actual", used with speed and distance scales, are included only to inform the plotter that both relative and actual problems may be solved. When relative distance is used, the corresponding speed must be relative.

Time-speed-distance scales are based on the formula: Distance = speed x time. These scales are so arranged that, by marking off any two known values in this formula and laying a straightedge through the points so marked, the correct value of the third quantity is the point of intersection on the third scale.

It was observed (in figure 15-5) that the contact traveled 7000 yards in 8 minutes. What is the contact's SRM? On the time scale locate 8 minutes and on the distance scale locate 7000 yards. Draw a straight line through these two points and extend it across the speed scale. The line will cross the speed scale at 26.5 knots, this is the SRM.

3-MINUTE RULE

Another shortcut in determining speed or distance traveled is the method known as the 3-minute rule. It is a simple method of solving for relative speed, without having to use the logarithmic scales. The rule is based on the number of yards the contact travels in 3 minutes. Explanation of the 3-minute rule follows.

1. One knot equals 1 nautical mile per hour.

2. One knot equals 2000 yards per 60 minutes.

3. If 1 knot equals 2000 yards per 60 minutes, then by reducing the distance traveled in 3 minutes, it is found that a ship covers a distance of 100 yards.

$$\frac{3}{60} \text{ or } \frac{1}{20} \times 2000 = 100\text{yards}$$

4. Therefore, for every 3 minutes of travel, each knot of speed represents a distance of 100 yards. Thus, if a ship travels 1200 yards in 3 minutes, its speed is 12 knots. (Point off or drop the two places from the right side of the number being divided.)

To summarize the 3-minute rule: The number of hundreds of yards traveled by a ship in 3 minutes is the speed of that ship in knots.

VECTOR DIAGRAM

Thus far we have concerned ourselves with only the relative plot, i.e.: DRM, SRM, and MRM. We have not mentioned the true course and speed of the contacts involved, which at the beginning of this discussion we found was a direct cause of the effect known as relative motion. To determine the true course and speed of a contact, we must develop a vector diagram.

A vector is a straight line representing direction of movement and speed of movement. Direction (course) is indicated by drawing the line from the center of the maneuvering board toward the direction indicated on the outer bearing circle. (See figure 15-6.) Speed is indicated by the length of the vector drawn to scale.

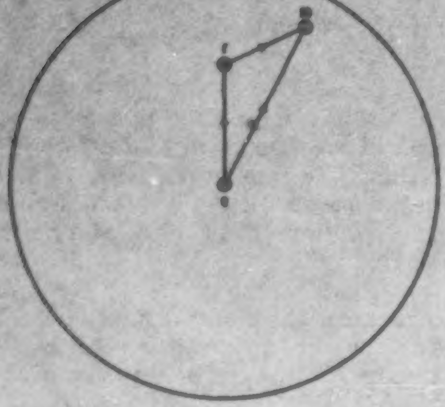
The small letter "e" is always at the center of the maneuvering board; small letter "r" is used at the arrowhead of the speed vector for own ship; and small letter "m" is used at the arrowhead of the speed vector of the other ship.

A vector diagram, frequently referred to as a speed triange, is illustrated in figure 15-6. This diagram is made up of six factors:

1. Course of reference ship-direction from e to r: e ⟶ r

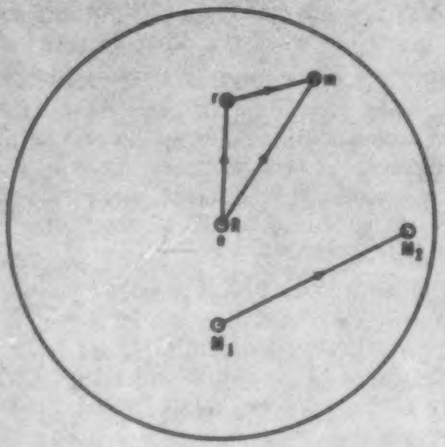
2. Speed of reference ship-distance from e to r: e ⟶ r

3. Direction of relative movement (DRM) of maneuvering ship with respect to reference ship-distance from r to m: r ⟶ m



38.65(58)A

Figure 15-6.—Vector diagram.



38.65(58)A

Figure 15-7.—Complete relative movement plot.

4. Speed of relative movement (SRM) of maneuvering ship with respect to reference ship-distance from r to m: r——→m
5. Course of maneuvering ship-direction from e to m: e——→m
6. Speed of maneuvering ship-distance from e to m: e——→m

With e always at the center, maneuvering ship's course and speed and own course and speed have the same point of origin at the center. The line drawn from the head of own speed vector r to the head of the maneuvering ship's speed vector m is always the direction of relative movement. The direction of relative movement will always go from r to m (see figure 15-7) and the arrowhead is always placed at m. The speed scale used in the vector diagram must be common to all vectors.

As can be seen, each line (or vector) represents both direction (course) and speed. The diagram must be labeled properly for correct interpretation.

MANEUVERING BOARD TECHNIQUE

Basically, the solution of all maneuvering board problems is the same. The relative plots must be connected, giving the M_1-M_2-M_x line, which is the DRM. Then the vector diagram must be completed. Once it is completed, the problem must be solved and the desired course, speed, etc., can be picked from the vector diagram. Four of the six values of a vector diagram (and time involved) must be known before any solution can be obtained.

In addition to basic problems that follow, plotters should know how to set up a maneuvering board to indicate a tactical organization and disposition of own force. This information can be obtained from ATP 1, Volume I.

Dutton's Navigation and Piloting and the Maneuvering Board Manual (Pub No. 217) serve as excellent references for information on uses of the maneuvering board not covered in this chapter.

MANEUVERING BOARD HINTS

The following guidelines are offered in working maneuvering board problems.

1. Read the problem carefully and understand it before proceeding with the solution. Check all numbers.
2. Determine the largest scale possible, both for speed and distance, and keep the same scale throughout the problem. Different scales may be used, however, for relative plot and vector diagram.

3. Avoid using reciprocals. This is particularly true when determining DRM if your ship is maneuvering on another ship.

4. Measure carefully. It is easy to pick off the wrong circle or make an error of 10° in a direction. Read the plotted answers accurately.

5. Plot only true bearings. Convert relative to true before plotting.

6. Label all points and put arrowheads on all lines.

7. Remember that relative speed is from r to m, relative movement from M_1 to M_2.

8. Actual speed vectors always originate at the center of the board.

9. In actual problems, at least three plots are needed on a contact for accurate solutions.

10. Work a problem one step at a time.

11. Be methodical, be careful, and practice diligently.

CLOSEST POINT OF APPROACH

The closest point of approach (CPA) of a contact to the reference ship is the shortest distance between the extended relative movement line and the center of the maneuvering board and must be a line perpendicular to the relative movement line. The direction of this line from the center of the maneuvering board to the outer bearing circle is the true bearing of CPA.

Suppose that at 0530 CIC reports a contact bearing 236° at 18,000 yards. Ten minutes later the contact bears 229° at 14,000 yards. The plotter will want to figure the following data:

1. Direction of relative movement (DRM) of contact with respect to own ship.
2. True bearing of contact when it reaches minimum range.
3. Minimum range to contact (range to CPA).
4. Relative bearing of contact when it reaches CPA.
5. Speed of relative movement (SRM) of contact.
6. Time at which contact will reach CPA.

First, plot the M_1 and M_2 positions of the contact. (See figure 15-8.) Mark on the bearing circle the first bearing (236°) and lay parallel rulers on that mark and the center of the board. For the range, select the largest scale practicable. Because of the range (18,000 yards) a 2:1 scale seems most logical. Place a dot where the bearing line crosses the 9 ring. This dot is the M_1 position. Plot the M_2 position in the same manner. Draw a line between the M_1 and M_2 positions, and extend the line past the center of the board as shown. To find direction of relative movement (DRM), lay parallel rulers along the relative movement line (M_1 to M_2), walk them to the center of the board, and draw a short line through the bearing circle. The DRM (or relative course) is 080°.

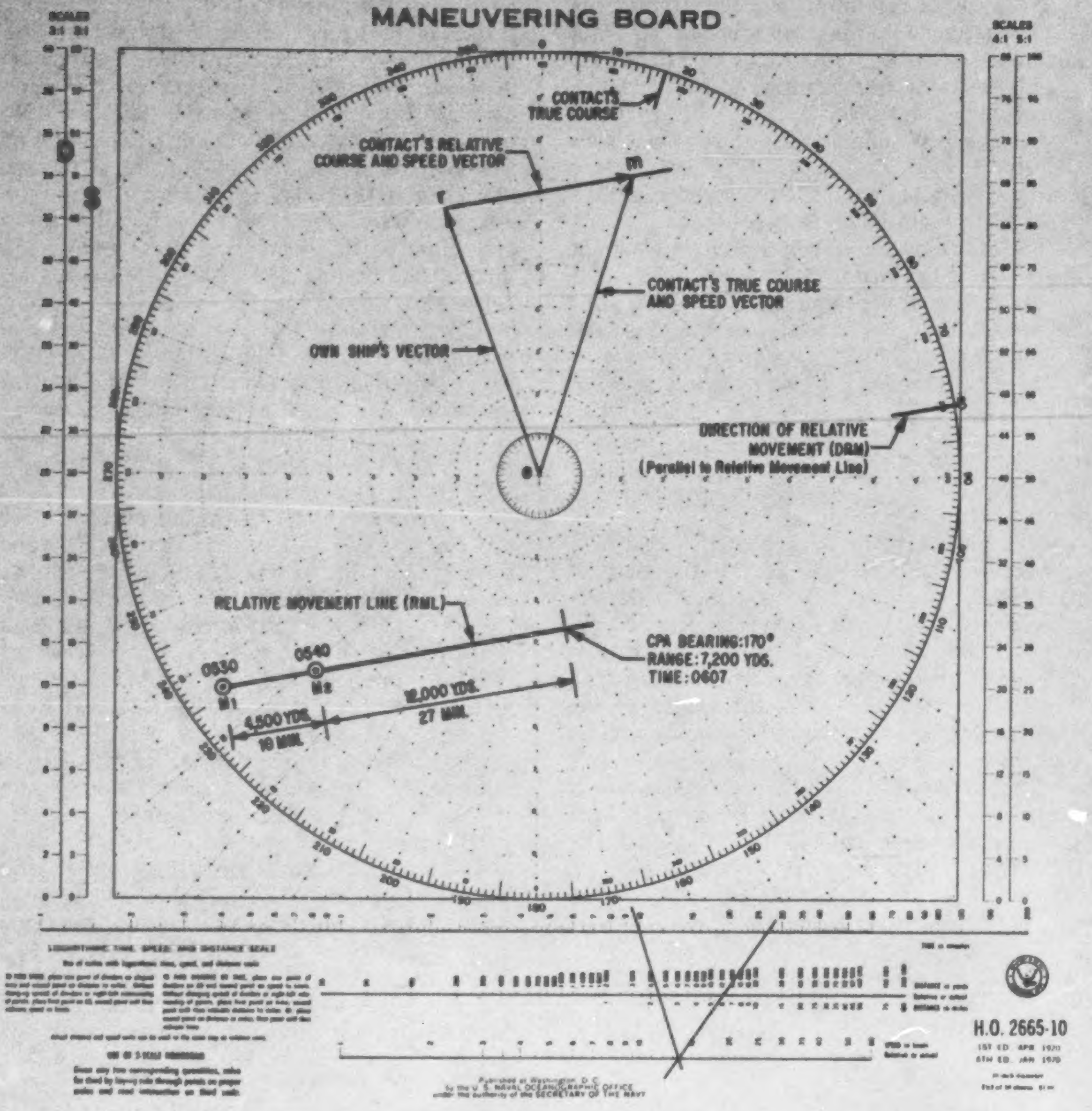
Two methods may be used to find the bearing of CPA. The first method is to add 90° to or subtract 90° from DRM. The plotter should be able to tell by inspection whether to add or subtract. In this example, he must add. Hence, at CPA, contact will bear 170° (080° + 90° = 170°).

A second way to find the bearing of contact at CPA is to use a right angle triangle. Lay one side of the right angle along the relative movement line (RML), move the triangle along the RML until the vertical side passes through the center of the board. Draw a line across the relative movement line. Lay the parallel rulers along this line and the center of the board. Read the bearing on the bearing circle.

To find the range of CPA, use dividers to measure the distance on the proper ratio scale at the side of the board. In our example, the range is 7200 yards.

At times it helps to know what the relative bearing of CPA will be. To find relative bearing, subtract own ship's heading from the true bearing. Suppose that own ship's course is 340°. Obviously, one cannot subtract 340 from 170, but if 360 is added to the true bearing, the subtraction can be accomplished with no trouble. Thus, 170° + 360° = 530° and 530° - 340° = 190° = relative bearing of CPA.

We now know four of the CPA items, but we still must know speed of relative movement (SRM) and time of CPA. To find SRM, measure the distance between $\underline{M}_1$ and $\underline{M}_2$ on the proper scale. This measurement is the distance traveled in 10 minutes. Mark those quantities on the nomogram at the bottom of the maneuvering


MANEUVERING BOARD
CONTACT'S TRUE COURSE
CONTACT'S RELATIVE COURSE AND SPEED VECTOR
r
m
CONTACT'S TRUE COURSE AND SPEED VECTOR
OWN SHIP'S VECTOR
e
DIRECTION OF RELATIVE MOVEMENT (DRM)
(Parallel to Relative Movement Line)
RELATIVE MOVEMENT LINE (RML)
0530
0540
M1
M2
CPA BEARING:170°
RANGE:7,200 YDS.
TIME:0607
4,500 YDS.
10 MIN.
12,000 YDS.
27 MIN.
SCALES
H.O. 2665-10
Published at Washington, D.C.
by the U.S. NAVAL OCEANOGRAPHIC OFFICE
under the authority of the SECRETARY OF THE NAVY

36.65(69E)B

Figure 15-8.—Solving for CPA course and speed.

board and find speed (explained earlier). Relative speed is 13.5 knots.

To find time of CPA, measure the distance from M_2 to CPA. With this quantity and relative speed, again go the nomogram. Required information is the time required for the contact to get to CPA. Add this time (27 minutes) to the time at which the contact was at M_2. Time of CPA is 0607.

COURSE AND SPEED PROBLEM

To illustrate the procedures used to obtain the course and speed of a contact, let's use the situation in the previous problem.

Much of the information obtained in the CPA problem is also used to figure the contact's course and speed. For example, DRM and SRM determine the direction and length of the vector rm in the vector diagram.

In the previous problem, own ship's course and speed are 340°T and 20 knots. (See figure 15-8). This vector is layed out from the center along the 340° radial line to circle 6.7 (3:1 distance scale), and labeled er. Since it originates in the center of the maneuvering board, it is a true vector.

As previously discussed, DRM and the vector rm are always parallel, and the direction M_1 to M_2 is always the same direction r to m. Thus, if the DRM is paralleled up to the end of the er vector, the origin and direction of the rm vector are established. This is the relative course of the contact.

The relative speed (SRM) was determined to be 13.5 knots. This is the length of the vector rm. Using dividers, 13.5 knots is measured on the 3:1 scale and layed off from the er vector along the relative course line. Now the direction and length of the vector rm have been determined. Thus, the vector rm indicates the relative course and relative speed of the contact.

To determine the true course and speed of the contact, simply complete the vector diagram by drawing a line from the center of the maneuvering board to the end of the rm vector. This line is the em vector; its direction indicates the target's true course, and its length indicates the target's true speed. In this example the contact is on course 017°, speed 22 knots.

NEW CPA

The CPA problem just solved shows that there is nothing to worry about from the other ship so long as both ships continue on their present courses and speeds, but what happens if one ship changes course or speed?

Naturally, if the contact makes a change, the plotter must work out an entirely new problem.

If own ship is going to change course and/or speed, however, it makes sense to determine a new CPA before the change. This procedure may prevent putting own ship into possible danger. A new CPA can be found by using a vector diagram to solve for a new relative movement and relating the new rm to the old problem.

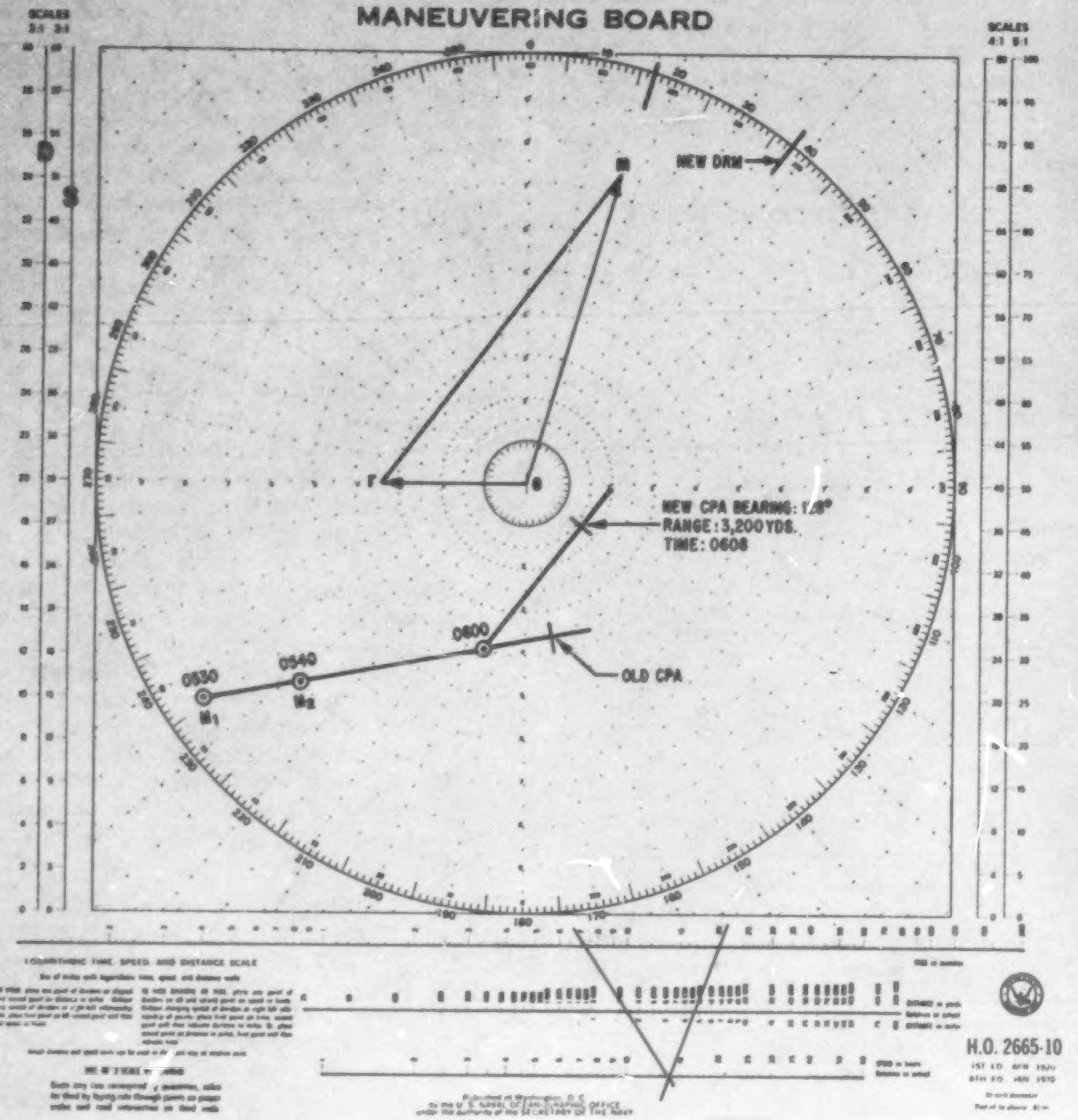
Suppose that own ship is a DD, scheduled to rendezvous with a CV, and that the night order book contains an order to change course to 270° and speed to 10 knots at 0600.

In actual practice this problem would be worked out on the same board as the one in figure 15-8; but, to avoid confusion, a new board is used in our example. (See figure 15-9). Needed information: plot the old relative movement line and contact's true course and speed vector em on figure 15-9.

First, determine contact's 0600 position on the relative movement line. (Remember that relative movement was computed on the 2:1 scale.) Contact was at M_2 at 0540. Therefore, go to the nomogram with relative speed (13.5 knots) and time (20 minutes). Mark this distance (9000 yards) from M_2 and label the position 0600.

Draw in the new own ship's vector 270° at 10 knots. (This vector was on the 3:1 scale.) Label own ship's vector er. Complete the triangle for the new relative movement rm. Walk the rulers to the center of the circle and draw a line across the bearing circle to find the new DRM, 038°. Walk the rulers down to the 0600 position and draw a line past the center of the circle in the new direction of relative movement. The new DRM plus 90° equals true bearing of the new CPA, 128°.

Measure the distance between the 0600 position and the new CPA. From the nomogram, find the time required to traverse that distance (08 minutes). New time of CPA is 0608, at distance 3200 yards.


MANEUVERING BOARD
NEW DRM
NEW CPA BEARING: 128°
RANGE: 3,200 YDS.
TIME: 0608
0530
0540
0600
M_1
M_2
OLD CPA
H.O. 2665-10

36.65(58)D

Figure 15-9.—Solving for a new CPA.

TRUE AND APPARENT WIND

True wind is the speed of wind and the true direction from which it blows, as measured at a fixed point on the Earth. Apparent wind is the speed and true direction from which wind blows as measured at a point that is moving relative to the Earth's surface.

Problem 1 (Measuring True Wind)

Reference: Figure 15-10
Scale: 2:1 in knots.

Situation: A carrier on course 030°, speed 15 knots, measures apparent wind as 20 knots from 062°.

Required: Direction and velocity of true wind.

Solution:

1. Draw vector er for carrier's course and speed.
2. From r draw apparent wind vector, 20 knots, in the direction 242° (062° + 180°) or with apparent wind. Label vector rw.
3. Connect e and w. Vector ew represents true wind. Note that the direction from which it blows is given as the answer.

Answer: True wind 10.8 knots from 109.5°.

Problem 2 (Measuring Apparent Wind)

Reference: Figure 15-11
Scale: 2:1 in knots
Situation: A ship is on course 075°, speed 18 knots. True wind is 7 knots from 170°.

Required: Speed and direction of apparent wind.

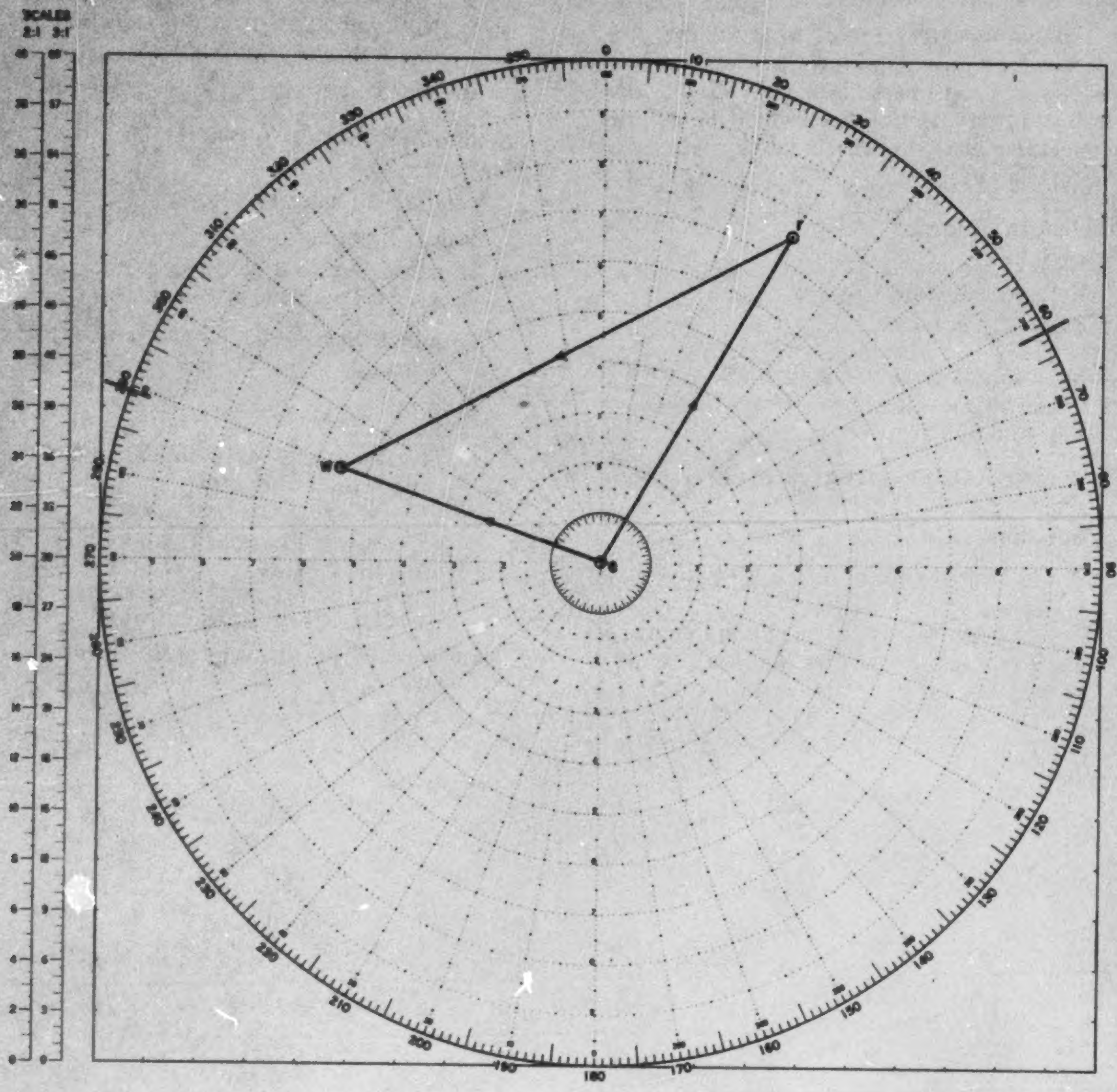
Solution:

1. Draw vector er for ship's course (075°) and speed (18 knots).

2. Draw vector ew with true wind toward 350° at 7 knots.

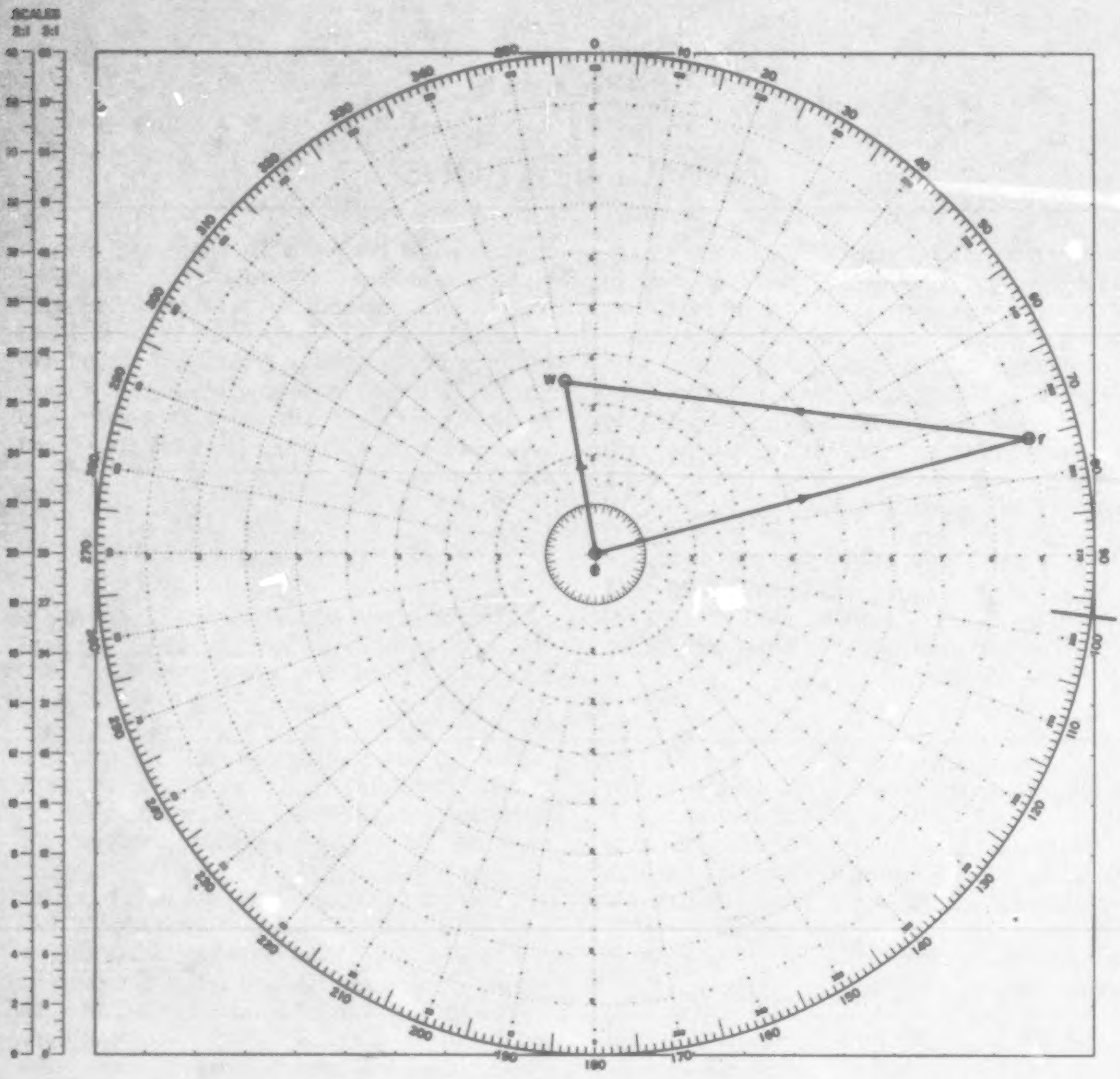
3. Connect rw, apparent wind.

Answer: Apparent wind 18.7 knots from 097°.


SCALES
2:1
3:1
W
T
e

112.47

Figure 15-10.—Solving for true wind speed and direction.


SCALES
2:1 3:1
W
T
e
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350

112.48

Figure 15-11.—Solving for Apparent wind speed and direction.

CHAPTER 16

COMMUNICATIONS

Quartermasters must be familar with communication systems and methods used in the Navy. Communications are grouped into two basic categories: interior and exterior. Interior communications are concerned only with exchange of information between individuals, divisions, and departments aboard a single ship or station. Exterior communications deal with conveying information between two or more ships, stations, or commands.

Most naval communications are conducted in the form of messages, which may be delivered in a variety of ways. The most common methods of delivery are messenger, electronic equipment, visual, and sound.

Interior communications are carried out by direct contact between two people, by messenger, sound-powered or ship's service telephones, MC systems, or such visual methods as the rudder angle indicator and engine order telegraph. All of these methods are discussed in the Seaman manual and, therefore, are not elaborated on here. This chapter presents information on apparatus and procedures of exterior communications.

Ship's external communications are conducted by using physical delivery, telecommunications, or any combination of the two methods. Telecommunications includes any transmission or reception of signs, signals, writing, images, or sound by visual, wire, radio, or other electromagnetic systems.

In delivering each communication, transmitting stations must take into account the precedence, security requirement, and limitations of the available equipment. From a security standpoint, the order of desirability of the various methods is: (1) messenger, (2) registered mail, (3) approved wire circuit, (4) ordinary mail, (5) nonapproved wire circuit, (6) visual, (7) sound systems, and (8) radio. Of these methods, Quartermasters normally are concerned only with radio (radiotelephone) and visual systems.

VOICE RADIO

The radiotelephone, commonly known as the voice radio, is an effective and convenient method of naval communications. It is used extensively for ship-to-ship tactical communication, for convoy work, for the control of airborne aircraft, and for countless tasks requiring rapid, short-range communications. Small vessels, such as district craft, rely almost entirely upon voice radio.

Voice radio supplements both radiotelegraph and visual methods of communications—it does not replace either form. It has the advantages of simplicity of operation and direct transmission of the spoken word, but ease of operation has led to abuse. Careless use of voice procedure, plus overloaded circuits, has created much confusion at times when good communication was imperative. Whether in a small boat or aboard ship, the Quartermaster should know the operation of this equipment and use proper voice radio procedures at all times.

OPERATION

Voice radio is considered the least secure means of communication. A message sent by radio is open to interception by anyone who has the necessary receiving equipment and is within reception range. Under most circumstances, the following practices are specifically forbidden:

1. Violation of radio silence.
2. Unofficial conversation between operators.
3. Transmitting in a directed net without permission.
4. Excessive tuning and testing.
5. Unauthorized use of plain language.
6. Transmission of an operator's name or personal sign.
7. Use of unauthorized prowords.
8. Linkage or compromise of classified call signs and address groups by plain language disclosures or association with unclassified call signs.
9. Unauthorized use of plain language in place of applicable prowords.
10. Profane, indecent, or obscene language.

Several desirable techniques you should acquire in operating a microphone include–

1. Listen before transmitting. Break-ins cause confusion.
2. Speak clearly and distinctly. Slurred syllables and clipped speech are difficult to understand.
3. Speak slowly. Give the recorder a chance to understand the entire message the first time. By this procedure, you save time and avoid repetitions.
4. Avoid extremes of pitch in voice modulation.
5. Be natural. Maintain a normal speaking rhythm. Send your message phrase by phrase instead of word by word.
6. Use standard pronunciation, avoiding regional dialects.
7. Keep correct distance between lips and microphone. A distance of about 2 inches is correct for most microphones.
8. Speak in a moderately strong voice to override background noises.
9. Shield your microphone. While transmitting, keep your head and body between sources of noise and the microphone.
10. Keep the volume of the handset earphone low.
11. Keep speaker volumes down to a moderate level.
12. Give an accurate evaluation in response to a request for a radio check.
13. Pause momentarily, when possible, and interrupt your carrier. Pausing allows any other station with higher precedence traffic to break in.
14. Follow closely prescribed procedures. Up-to-date radiotelephone procedure appears in the effective edition of ACP 125.
15. Transact your business and get off the air. Preliminary calls are unnecessary when communications are good and the message is short.
16. Do not hold the microphone button in the push-to-talk position until ready to transmit.
17. Apply firm pressure to the microphone button to prevent unintentional release and consequent signal interruption.

Letter	Phonetic Alphabet	Pronunciation Guide	International Morse Code
A	ALFA	AL FAH	• —
B	BRAVO	BRAH VOH	— • • •
C	CHARLIE	CHAR LEE	— • — •
D	DELTA	DELL TAH	— • •
E	ECHO	ECK OH	•
F	FOXTROT	FOKS TROT	• • — •
G	GOLF	GOLF	— — •
H	HOTEL	HOH TELL	• • • •
I	INDIA	IN DEE AH	• •
J	JULIETT	JEW LEE ETT	• — — —
K	KILO	KEY LOH	— • —
L	LIMA	LEE MAH	• — • •
M	MIKE	MIKE	— —
N	NOVEMBER	NO VEM BER	— •
O	OSCAR	OSS CAH	— — —
P	PAPA	PAH PAH	• — — •
Q	QUEBEC	KEH BECK	— — • —
R	ROMEO	ROW ME OH	• — •
S	SIERRA	SEE AIR RAH	• • •
T	TANGO	TANG GO	—
U	UNIFORM	YOU NEE FORM	• • —
V	VICTOR	VIK TAH	• • • —
W	WHISKEY	WISS KEY	• — —
X	XRAY	ECKS RAY	— • • —
Y	YANKEE	YANG KEY	— • — —
Z	ZULU	ZOO LOO	— — • •

*NOTE: ROGER will continue to be used as a proword; ROMEO will not be used as a proword.

Number	Phonetic Alphabet	International Morse Code
1	WUN	• — — — —
2	TOO	• • — — —
3	TREE	• • • — —
4	FOW-ER	• • • • —
5	FIFE	• • • • •
6	SIX	— • • • •
7	SEV-EN	— — • • •
8	AIT	— — — • •
9	NIN-ER	— — — — •
0	ZE-RO	— — — — —

17.20

Figure 16-1.—Phonetic and Morse code alphabet.

PRONOUNCING LETTERS AND NUMERALS

When necessary to identify any letter of the alphabet, use the standard phonetic alphabet. Refer to figure 16-1. Take care to distinguish numerals from similarly pronounced words. Preceding numbers, you may use the proword FIGURES.

The numeral 0 is always spoken as ZERO, never as OH. It is written as 0. Decimal points are spoken as DAY SEE MAL. Example: 123.4 is spoken as "Wun too tree day-see-mal fow-er."

Numbers will be transmitted digit by digit except that exact multiples of thousands may be spoken as such. Examples:

Numbers	Spoken As
44	fow-er fow-er
90	nin-er ze-ro
136	wun tree six
500	fife ze-ro ze-ro
1,478	wun fow-er sev-en ait
7,000	sev-en tou-sand
16,000	wun six tou-sand
812,681	ait wun too six ait wun

Some special instances require procedures different from the normal digit-by-digit pronunciation. Ranges and distances given in mile units and speed given in knots, for instance, are always transmitted as cardinal numbers. Examples:

Numbers	Spoken As
10	ten
13	thur-teen
25	twen-ty fife
50	fif-ty
110	wun hun-dred ten
300	tree hun-dred

Bearings are always given in three digits and are transmitted digit by digit. Examples:

Bearings	Spoken As
090	ze-ro nin-er ze-ro
180	wun ait ze-ro
295	too nin-er fife

PROWORDS

Procedure words (prowords) are words and phrases used to speed the handling of radiotelephone messages. They perform the same functions and are used in the same manner as are prosigns in visual and radiotelegraph procedures. Many prosigns have the same meaning as prowords.

Following is a complete list of prowords, each with an explanation and the corresponding prosign, if one exists.

Proword	Explanation	Equivalent To
ADDRESS GROUP	The group that follows is an address group.	
ALL AFTER	The portion of the message to which I have reference is all that which follows ____________.	AA
ALL BEFORE	The portion of the message to which I have reference is all that which precedes ____________.	AB
AUTHENTICATE	The station called is to reply to the challenge which follows.	
AUTHENTICATION IS	The transmission authentication of this message is	
BREAK	I hereby indicate the separation of the text from other portions of the message.	$\overline{\text{BT}}$

Proword	Explanation	Equivalent To
BROADCAST YOUR NET	Link the two nets under your control for automatic rebroadcast.	
CALL SIGN	The group that follows is a call sign.	
CORRECT	You are correct, or what you have transmitted is correct.	C
CORRECTION	An error has been made in this transmission. Transmission will continue with the last word correctly transmitted.	EEEEEEEE
	An error has been made in this transmission (or message indicated). The correct version is ______.	C
	That which follows is a corrected version in answer to your request for verification.	C
DISREGARD THIS TRANSMISSION-OUT	This transmission is in error. Disregard it. This proword shall not be used to cancel any message that has been completely transmitted and for which receipt or acknowledgment has been received.	EEEEEEEE $\overline{AR}$
DO NOT ANSWER	Stations called are not to answer this call, receipt for this message, or otherwise transmit in connection with this transmission. When this proword is employed, the transmission shall be ended with the proword "OUT."	F
EXECUTE	Carry out the purport of the message or signal to which this applies. To be used only with the Executive Method.	$\overline{IX}$ (5 sec dash)
EXECUTE TO FOLLOW	Action on the message or signal which follows is to be carried out upon receipt of the proword "EXECUTE." To be used only with the Delayed Executive Method.	$\overline{IX}$
EXEMPT	The addressees immediately following are exempted from the collective call.	XMT
FIGURES	Numerals or numbers to follow.	
FLASH	Precedence FLASH.	Z

Proword	Explanation	Equivalent To
FROM	The originator of this message is indicated by the address designator immediately following.	FM
GROUPS	This message contains the number of groups indicated by the numeral following.	GR
GROUP NO COUNT	The groups in this message have not been counted.	GRNC
I AUTHENTICATE	The group that follows is the reply to your challenge to authenticate.	
IMMEDIATE	Precedence IMMEDIATE	O
IMMEDIATE EXECUTE	Action on the message or signal following is to be carried out on receipt of the word EXECUTE. To be used only with the Immediate Executive Method.	$\overline{\text{IX}}$
INFO	The addressees immediately following are addressed for information.	INFO
I READ BACK	The following is my response to your instructions to read back.	
I SAY AGAIN	I am repeating transmission or portion indicated.	$\overline{\text{IMI}}$
I SPELL	I shall spell the next word phonetically.	
I VERIFY	That which follows has been verified at your request and is repeated. To be used only as a reply to VERIFY.	
MESSAGE	A message which requires recording is about to follow. Transmitted immediately after the call. (This proword is not used on nets primarily employed for conveying messages. It is intended for use when messages are passed on tactical or reporting nets.)	
MORE TO FOLLOW	Transmitting station has additional traffic for the receiving station.	B
NET NOW	All stations are to net their radios on the unmodulated carrier wave which I am about to transmit.	

Proword	Explanation	Equivalent To
NUMBER	Station serial number.	NR
OUT	This is the end of my transmission to you and no answer is required or expected.	$\overline{\text{AR}}$
OVER	This is the end of my transmission to you and a response is necessary. Go ahead; transmit.	K
PRIORITY	Precedence PRIORITY.	P
READ BACK	Repeat this entire transmission back to me exactly as received.	G
RELAY (TO)	Transmit this message to all addressees (or addressees immediately following this proword). The address component is mandatory when this proword is used.	T
ROGER	I have received your last transmission satisfactorily.	
ROUTINE	Precedence ROUTINE.	R
SAY AGAIN	Repeat all of your last transmission. Followed by identification data, it means "Repeat ______ (portion indicated)."	$\overline{\text{IMI}}$
SERVICE	The message that follows is a SERVICE message.	SVC
SIGNALS	The groups which follow are taken from a signal book. (This proword is not used on nets primarily employed for conveying signals. It is intended for use when tactical signals are passed on non-tactical nets).	
SILENCE (Repeated three or more times)	Cease transmissions on this net immediately. Silence will be maintained until lifted. (When an authentication system is in force, the transmission imposing silence is to be authenticated.)	$\overline{\text{HM}}$ $\overline{\text{HM}}$ $\overline{\text{HM}}$
SILENCE LIFTED	Silence is lifted. (When an authentication system is in force the transmission lifting silence is to be authenticated.)	

Proword	Explanation	Equivalent To
SPEAK SLOWER	Your transmission is at too fast a speed. Reduce speed of transmission.	
STOP REBROADCASTING	Cut the automatic link between the two nets that are being rebroadcast and revert to normal working.	
THIS IS	This transmission is from the station whose designator immediately follows.	DE
TIME	That which immediately follows is the time or date-time group of the message.	
TO	The addressees immediately following are addressed for action	TO
UNKNOWN STATION	The identity of the station with whom I am attempting to establish communication is unknown.	$\overline{AA}$
VERIFY	Verify entire message (or portion indicated) with the originator and send correct version. To be used only at the discretion of or by the addressee to which the questioned message was directed.	J
WAIT	I must pause for a few seconds.	$\overline{AS}$
WAIT-OUT	I must pause longer than a few seconds.	$\overline{AS}$ $\overline{AR}$
WILCO	I have received your signal, understand it, and will comply. To be used only by the addressee. Since the meaning of ROGER is included in that of WILCO, the two prowords are never used together.	
WORD AFTER	The word of the message to which I have reference is that which follows ______.	WA
WORD BEFORE	The word of the message to which I have reference is that which precedes ______.	WB
WORDS TWICE	Communication is difficult. Transmit (ting) each phrase (or each code group) twice. This proword may be used as an order, request, or as information.	
WRONG	Your last transmission was incorrect. The correct version is ______.	

Table 16-1.—Basic Format for Standard Navy Messages

Parts	Components	Elements	Contents	Remarks
HEADING	Procedure	Handling instructions.	Routing indicators.	Used in tape relay procedures only.
		Call.	Prosign F; station(s) called; prosign $\overline{AA}$; prosign XMT; exempted calls; prosign DE and station calling.	Prepared by communication personnel.
		Transmission identification.	Station serial number.	Prepared by communication personnel. (Not presently authorized for use in messages between ships or in messages from ships to shore stations.
		Transmission instructions.	Prosigns T, G, F, L; operating signals; call signs; address groups; plain language.	Prepared by communication personnel.
	Preamble	Precedence; date-time group; message instructions.	Precedence prosign; date and time (in digits) and zone suffix; operating signals and prosign $\overline{IX}$.	Precedence assigned by originator; date-time group and message instructions normally assigned by communication personnel.
	Address	Originator's sign; originator.	Prosign FM; originator's designation (address group, call sign, or plain language).	Addressees determined by originator. Communication personnel provide call signs, address groups, and appropriate prosigns.
		Action addressee sign; action addressee.	Prosign TO; action addressee designation (address groups, call signs, or plain language).	
		Information addressee sign; information addressee.	Prosign INFO; information addressee designation (address groups, call signs, or plain language).	
		Exempted addressee sign; exempted addressee.	Prosign XMT; exempted addressee designation (address groups, call signs, or plain language).	
	Prefix	Accounting information; group count.	Accounting symbol; group count.	Determined by communication personnel.
BREAK			Prosign $\overline{BT}$.	
TEXT	Text	Subject matter.	Internal instructions; basic idea of originator.	First group of text contains classification of message. or UNCLAS; and SVC (service message).
BREAK				
ENDING	Procedure	Time group.	Hours and minutes expressed in digits; zone suffix, when appropriate.	Determined by communication personnel.
		Final instructions.	Prosigns B, $\overline{AS}$, C; operating signals.	
		Ending sign.	Prosign K or $\overline{AR}$.	

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MESSAGE FORMS

Three military message forms are used in radiotelephone procedure. These forms are–

1. Plaindress, in which the entire address is indicated outside of the text. Plaindress messages contain all the components of the basic message format, which may be seen in table 16-1, except that the call may serve as the address.
2. Abbreviated plaindress, which is designed for speed in traffic handling. The precedence, date, date-time group, and group count may be omitted from the heading of an abbreviated plaindress message.
3. Codress, which has the entire message address in its encrypted test.

Abbreviated plaindress is by far the most common form used in voice radio. Regardless of which form is employed, each message must contain the three major parts–heading, text, and ending.

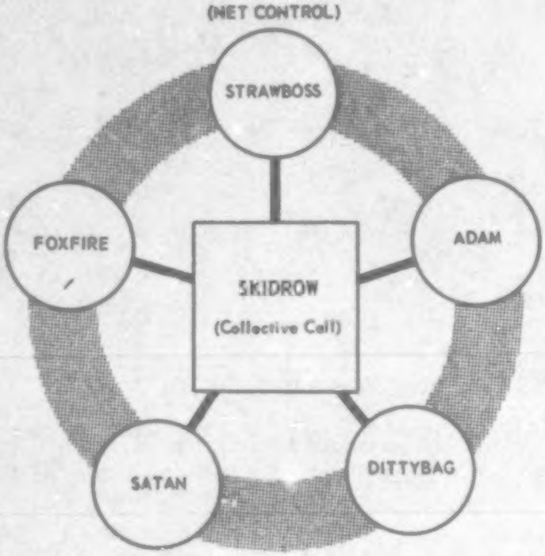
Heading

The heading of a radiotelephone message, like a visual message, may contain any or all of the components that make up the heading (procedure, preamble, address, and prefix). More often than not, however, it contains only the call, preceding the text. One explanation for such general use of the abbreviated form is that, in radiotelephone communication, the station originating is nearly always in direct communication with the station addressed.

Text

The text of the message is the basic thought or idea the originator wishes to communicate. It may be in the form of plain language, signals, code words, encrypted groups, or numerals.

Difficult words or groups within a text of a plain language message are spelled out, using the phonetic alphabet. Groups or words to be spelled are preceded by the proword I SPELL. If the operator can pronounce the word, he should do so before and after spelling.



41.31

Figure 16-2.–Radiotelephone net.

Ending

Every radiotelephone message ends with the proword OVER or OUT. With the use of OVER, the sender tells the receiver to go ahead and transmit, or: "This is the end of my message to you, and a response is necessary." With the use of OUT, the sender tells the receiver: "This is the end of my transmission to you, and no response is necessary." It is never necessary to use OVER and OUT together.

RADIOTELEPHONE PROCEDURE

Before you start your study of radiotelephone procedure, you should be warned that communication procedure is liable to continual improvement and change. You can keep up with changes only by continued study of current communication instructions.

Radiotelephone transmissions used for illustrative purposes are assumed to pass over the net shown in figure 16-2.

Calling and Answering

Radiotelephone communication is established by a preliminary call, which takes the form of an individual or a collective call.

Individual call: In this example a single station is called; if two or more stations are called, they will reply in alphabetical order of call signs.

FOXFIRE–. . . . . Call sign of receiving station.

THIS IS– . . . . From.

STRAWBOSS–.Call sign of the station calling .

OVER–. . . . . Go ahead, transmit.

The reply is in the same form: STRAWBOSS–THIS IS FOXFIRE–OVER.

Collective call: When stations on the net are assigned a collective call, that call is used if all the stations are addressed. If, for some reason, one or more stations are to be exempted from the call, the collective call contains the proword EXEMPT, followed by the call signs of the exempted stations. Example:

SKIDROW– . . . . Collective call.
EXEMPT–. Exempt.
DITTYBAG–. Call sign of the exempted station.
THIS IS–. . . . . From.
STRAWBOSS–. Call sign of the station calling.
OVER– . . . . Go ahead, transmit.

ADAM, FOXFIRE, and SATAN now answer in alphabetical order of their call signs.

Abbreviated Call

The call sign of the called station may be omitted when the call is part of an exchange of transmissions between stations and when no confusion will result. Example: THIS IS ADAM–OVER.

Repetitions

When parts of the heading, text, or ending of a message are missing or are doubtful, repetition is requested by the receiving station. The proword SAY AGAIN (alone or with ALL BEFORE, ALL AFTER, WORD BEFORE, WORD AFTER, _T_) is used for this purpose. In complying with such requests, the transmitting station identifies the portion to be repeated. Examples: DITTYBAG sends a message to SATAN. SATAN misses the word after "ship." SATAN transmits:

> DITTYBAG–THIS IS SATAN–SAY AGAIN–WORD AFTER SHIP–OVER

DITTYBAG transmits:

> SATAN–THIS IS DITTYBAG–I SAY AGAIN–WORD AFTER SHIP–SIGHTED–OVER

Upon receipt of the doubtful portion, DITTYBAG receipts for the entire message with ROGER.

Repetitions may be given in plain language messages by natural phrases or by individual words. In encoded or encrypted messages, they are made by individual characters.

Correcting an Error

When an error is made by the transmitting operator, the proword CORRECTION is sent. The operator then repeats the last word, group, proword, or phrase correctly sent, corrects the error, and proceeds with the message. (NOTE: The first group of all plain language messages consists of the message classification.) Example 1:

> ADAM–THIS IS STRAWBOSS–TIME ONE ZERO ONE TWO ZULU–BREAK–UNCLAS–CONVOY ROMEO THREE–CORRECTION–CONVOY SIERRA ROMEO THREE–SHOULD ARRIVE–ONE SIX THREE ZERO LIMA–OVER

If the error is not discovered until the operator is some distance beyond it, he may make the correction at the end of the message. He must be careful to identify the exact portion he is correcting. Example 2:

> ADAM–THIS IS STRAWBOSS–TIME ZERO SIX THREE ZERO ZULU–BREAK–UNCLAS–ARE YOU RIGGED FOR HEAVY WEATHER–CORRECTION–TIME ZERO SIX FOUR ZERO ZULU–OVER

Canceling a Message During a Transmission

During the transmission of a message, and preceding the transmission of the ending proword OVER or OUT, the message may be canceled by the proword DISREGARD THIS TRANSMISSION. (A message that has been transmitted completely can be canceled only by another message.) Example: During the transmission of a message, STRAWBOSS discovers he is giving it to the wrong station. STRAWBOSS transmits:

> FOXFIRE–THIS IS STRAWBOSS–ROUTINE–TIME ZERO SIX ZERO TWO ZULU–UNCLAS–COMMENCE UNLOADING AT DAWN SIXTEENTH–PROCEED–DISREGARD THIS TRANSMISSION–OUT

Do Not Answer

When it is imperative that called stations not answer a transmission, the proword DO NOT ANSWER is transmitted immediately after the call. The complete transmission is sent twice. Example:

> SKIDROW–THIS IS STRAWBOSS–DO NOT ANSWER–TIME ONE ZERO THREE SIX ZULU–BREAK–NOVEMBER YANKEE DELTA PAPA–I SAY AGAIN–SKIDROW–THIS IS STRAWBOSS–DO NOT ANSWER–TIME ONE ZERO THREE SIX ZULU–BREAK–NOVEMBER YANKEE DELTA PAPA–OUT

Verifications

When verification of a message is requested, the originating station verifies the message with the originator, checks the cryptography (if the message is encrypted), and sends the correct version. Example 1:

> STRAWBOSS–THIS IS ADAM–VERIFY YOUR ONE ZERO ZERO EIGHT ZERO ONE ZULU–ALL BEFORE TEXT–OVER

STRAWBOSS transmits:

> THIS IS STRAWBOSS–ROGER–OUT

STRAWBOSS, after checking with the originating officer, finds the heading correct as transmitted previously. STRAWBOSS sends:

> ADAM–THIS IS STRAWBOSS–I VERIFY–MY ONE ZERO ZERO EIGHT ZERO ONE ZULU–ALL BEFORE BREAK–PRIORITY–TIME ONE ZERO ZERO EIGHT ZERO ONE ZULU–FROM STRAWBOSS–TO–ADAM–INFO–DITTYBAG–GROUPS ONE SEVEN–BREAK–OVER

ADAM transmits:

> THIS IS ADAM–ROGER–OUT

Example 2:

> STRAWBOSS–THIS IS SATAN–VERIFY MESSAGE TIME ZERO EIGHT FOUR FIVE ZULU–WORD AFTER PROCEED–OVER

STRAWBOSS transmits:

> THIS IS STRAWBOSS–ROGER–OUT

After checking with the originating officer, STRAWBOSS finds that he means HONGKONG instead of SHANGHAI as word after PROCEED. STRAWBOSS transmits:

> SATAN–THIS IS STRAWBOSS–CORRECTION–MY ZERO EIGHT FOUR FIVE ZULU–WORD AFTER PROCEED–HONGKONG–OVER

SATAN transmits:

> THIS IS SATAN–ROGER–OUT

Read Back

A check on transmission accuracy can be had by using the prowords READ BACK. READ BACK is used when you want your own message (or a portion of it) repeated back to you as received. (When the READ BACK procedure is employed, the proword ROGER need not be used to indicate receipt of a message.) Remember to identify the message portion you want read back. Transmit the READ BACK proword immediately after the call. Example:

ADAM–THIS IS STRAWBOSS–READ BACK TEXT–TIME ONE SIX THREE ZERO ZULU–BREAK–UNCLAS–CONVOY DELAYED ONE TWO HOURS–BREAK–OVER

ADAM replies:

THIS IS ADAM–I READ BACK TEXT–UNCLAS–CONVOY DELAYED ONE TWO HOURS–OVER

STRAWBOSS then sends:

THIS IS STRAWBOSS–THAT IS CORRECT–OUT

If the message is sent back incorrectly, it may be corrected by the proword WRONG, followed by the corrected version. In the preceding example, assume that ADAM made a mistake when he read back the message:

THIS IS ADAM–I READ BACK TEXT–UNCLAS–CONVOY DELAYED TWO ONE HOURS–OVER

STRAWBOSS corrects ADAM:

THIS IS STRAWBOSS–WRONG–UNCLAS–CONVOY DELAYED ONE TWO HOURS–OVER

ADAM reads back again:

THIS IS ADAM–UNCLAS–CONVOY DELAYED ONE TWO HOURS–OVER

STRAWBOSS ends the exchange with:

THIS IS STRAWBOSS–THAT IS CORRECT–OUT

Executive Method

The executive method is used to execute tactical signals so that two or more units can take action at the same time. Usually the abbreviated form is used in such messages. Executive messages contain the proword EXECUTE TO FOLLOW or IMMEDIATE EXECUTE, as appropriate, immediately after the call. The signal to carry out the meaning of the message is the proword EXECUTE. It may be sent shortly after transmission of the message.

Variations of the executive method are (1) the delayed executive method and (2) the immediate executive method. (In any event, a warning STANDBY precedes the proword EXECUTE.)

In our first example, the OTC sends a message to the task group by the delayed executive method.

SKIDROW–THIS IS STRAWBOSS–EXECUTE TO FOLLOW–CORPEN THREE FIVE SEVEN–OVER

All ships reply in alphabetical order:

THIS IS ADAM–ROGER–OUT
THIS IS DITTYBAG–ROGER–OUT
THIS IS FOXFIRE–ROGER–OUT
THIS IS SATAN–ROGER–OUT

When STRAWBOSS is ready to execute, he sends the executive signal. To save time, only one station is directed to receipt.

SKIDROW–THIS IS STRAWBOSS–STANDBY–EXECUTE–BREAK–ADAM–OVER

ADAM replies:

THIS IS ADAM–ROGER–OUT

In the immediate executive method the text of the message is transmitted twice, separated by I SAY AGAIN. The warning proword IMMEDIATE EXECUTE is used in the message instruction instead of EXECUTE TO FOLLOW. The executive signal itself follows in the final instructions of the message. Because only one transmission is made, the immediate executive method message does not allow stations to obtain verifications, repetitions, acknowledgments, nor cancellations before the message is executed. Example:

SKIDROW–THIS IS STRAWBOSS–IMMEDIATE EXECUTE–(BREAK)–TURN NINE–I SAY AGAIN–TURN NINE–STANDBY–EXECUTE–SATAN–OVER

SATAN receipts:

THIS IS SATAN–ROGER–OUT

Acknowledgment

An acknowledgment is a reply from an addressee indicating that he has received a certain message, understands it, and can comply with it. Note the difference between an acknowledgment and a receipt. The receipt means that the message was received satisfactorily. An important feature of the acknowledgment procedure is that only a commanding officer or his designated representative can authorize you to send an acknowledgment.

The request for an acknowledgment is the word ACKNOWLEDGE (not a proword) as the final word of the text. The reply is the proword WILCO. If the commanding officer can acknowledge at once, the operator may receipt for the message with WILCO because the meaning of ROGER is contained in WILCO. If the acknowledgment cannot be returned immediately, the operator receipts for the message with the proword ROGER, and WILCO is sent later. The return transmission to a request for an acknowledgment is either ROGER or WILCO. (Never use these prowords together.)

In the following example, the OTC sends a tactical signal. He desires acknowledgment from two ships.

SKIDROW–THIS IS STRAWBOSS–EXECUTE TO FOLLOW–BREAK–TANGO BRAVO–TACK–ONE FIVE–TACK–ZERO ZERO ZERO–TACK–ONE TWO–FOXFIRE–DITTYBAG–ACKNOWLEDGE–OVER

The commanding officer of DITTYBAG hears the message, understands it, and can comply. He directs his operator to acknowledge:

THIS IS DITTYBAG–WILCO–OUT

The commanding officer of FOXFIRE wishes to consider the message before acknowledging. His operator transmits:

THIS IS FOXFIRE–ROGER–OUT

When the commanding officer of FOXFIRE is ready to acknowledge, he has two choices of reply. He can send either:

STRAWBOSS–THIS IS FOXFIRE–WILCO–YOUR LAST TRANSMISSION–OUT

or: STRAWBOSS–THIS IS FOXFIRE–WILCO–YOUR EXECUTE TO FOLLOW–BREAK–TANGO BRAVO–TACK–ONE FIVE–TACK–ZERO ZERO ZERO–TACK–ONE TWO–OUT

When ready to execute, the OTC transmits:

SKIDROW–THIS IS STRAWBOSS–STANDBY–EXECUTE–ADAM–OVER

ADAM receipts as directed:

THIS IS ADAM–ROGER–OUT

VISUAL SIGNALING

The three principal methods of visual signaling are flashing light, semaphore, and flaghoist. The remainder of this chapter is concerned with these methods and the signaling procedures that the Quartermaster must know.

FLASHING LIGHT

The two types of flashing light communication are directional and nondirectional.

Directional transmissions are sent out by a signal searchlight that is pointed and trained directly at the receiver so as to be visible through a limited arc. It is the longest range visual signaling method.

Nondirectional signals are sent out from yardarm blinkers or a special nondirectional signaling lantern (DSL), which are operated from a transmission key located in the pilothouse or on the signal bridge. The light is visible in any direction away from the ship, thus affording the sender an effective way to communicate simultaneously with many addressees. Yardarm blinkers are restricted to nighttime use among ships in company.

International Morse Code

International Morse code is standard for all naval communications transmitted by flashing light or radiotelegraph. You must know it well before you can use flashing light equipment.

The international Morse code is a dot-dash system. It is not difficult to learn if you go about it the right way. Basically, it consists of sight patterns, which you must recognize. Each of the sight patterns is really a mental picture of dots and dashes arranged in a group. These groups consist of from one to six dots or dashes, or both. Each group represents a letter of the alphabet, a numeral, or punctuation. You'll be surprised how easy it is to learn them–with some practice. But don't neglect it–practice is the secret.

The international Morse code alphabet and number sight patterns, as well as the phonetic pronunciation for each, are shown in figure 16-1. They can be learned in one or two sittings. Experience shows that the best way to learn code is by wholes. The Radioman learns whole tonal sounds. Similarly, the Quartermaster and Signalman should learn by whole sight patterns. Do not break each character into dots and dashes that must be counted. Instead, try to learn each character as a complete mental picture. When you see one dot and one dash (. -), don't count them ("one dot, one dash") and then conclude it's the letter A you saw, but think the letter A as soon as you see the dot and dash.

Ask an experienced man to send to you with a searchlight, multipurpose light, or blinker card. Start by having him send you unknown individual letters or numbers. When you miss, ask him at once to tell you what the letter was, then have him flash it again. When you master each character, try code groups and, later, after you attain some proficiency, try plain language. Never try plain language first because receiving plain language tends to encourage guessing and actually slows the process of learning the code.

Use these code groups as a starter. Other exercises appear elsewhere in this chapter.

SNEVI GHSOM AT8LW QV072 ERPOL
FOX1R MINOF 34PRT ZXCVB IMTYH
EXCI9 EHOXA 92474 CRBDZ ULXUK
RHEDC HILDE DEL62 ROSE8 PLMON
IJBUH 8YGVT 6FC5R D4XES Z3WA2
QPWOE RITUY LAKSJ FDHGO NAILP
06293 48751 64209 89347 23690

You can make up all sorts of combinations. Just be sure they are code groups–not ordinary words–so you cannot anticipate what's coming next.

Once you become really proficient at code groups, you can graduate to plain language. Even then, try to avoid anticipating the next letter, because you may be wrong and find yourself really confused. In any event, you never will be a good code man if you fall into the bad habit of anticipating.

Tips on Sending

After your receiving ability progresses, try some sending. You'll find it easy to pick up. Remember that there is a definite physical limitation on the speed with which flashing light can be sent and still be readable. The manufacturer's specifications state that the 12-inch Navy signal searchlight can send up to 10 words a minute. A good sender and receiver can exceed this speed if the characters are made clearly and distinctly, with uniform spacing between them. Incidentally, speed doesn't necessarily mean noise. The light shutters can be moved quickly without banging them up and down.

A good rule to adopt is: Never send faster than you can receive. If you transmit a message at 12 words a minute and get a reply at the same rate, you'll be out of luck if you can read only 8 words a minute. It is preferable to send and receive a message correctly at 8 words a minute than to have to send it twice at a 12-word rate.

SEMAPHORE

Semaphore is much faster than flashing light for short-distance transmissions in clear daylight. Semaphore may be used to send messages to several addressees at once if they are in suitable positions. Because of its speed, semaphore is better adapted than are the other visual methods of long messages. When radio silence is imposed, semaphore is considered the best substitute for handling administrative traffic.

Although semaphore's usefulness is limited somewhat by its short range, it is more secure than light or radio because there is less change of interception by an enemy or unauthorized persons. Speed and security, therefore, are the two factors favoring the use of semaphore under daylight conditions.

Semaphore requires little in the way of equipment. The two hand flags attached to staffs are all you need. Usually the standard semaphore flags are 15 to 18 inches square, and each staff is long enough to enable the sender to grasp it firmly. The flags are similar to the OSCAR alphabet flag. Sometimes the PAPA flag is substituted. Most semaphore flags issued to the fleet today are fluorescent and are made of sharkskin. (When sender and receiver are very close to each other, as when ships are alongside for underway replenishment, no special equipment is necessary. The semaphore characters are made simply by moving the hands to the proper positions.)

When using fluorescent flags, your background while sending is relatively unimportant. With cotton flags, however, a good background must be selected. Otherwise, the receiving operator(s) may be unable to see your flags clearly.

Sending and Receiving

A description of a clear and effective method for learning semaphore communication follows. Take a look at figure 16-3. It shows how the semaphore alphabet and certain special signs used in connection with it are formed by means of your two flags. Before you try to memorize the position for the various letters and signs, practice moving your arms quickly and accurately to each of the various positions. In other words, hold a one-man position drill. Be careful not to confuse the right hand in the illustration with your left hand. The man in figure 16-3 is the sender, and you'll be looking at the illustrations as if you were the receiver.

In figure 16-4 you see a man swinging himself through a position drill. He moves his flags smartly to their positions. Notice, for example, that there's no mistaking his Bs for his As or Cs. Take a tip and do likewise, or you'll make a name for yourself as a Sloppy Joe on the semaphore stand. A sloppy sender spends his time repeating messages—because nobody can read them.

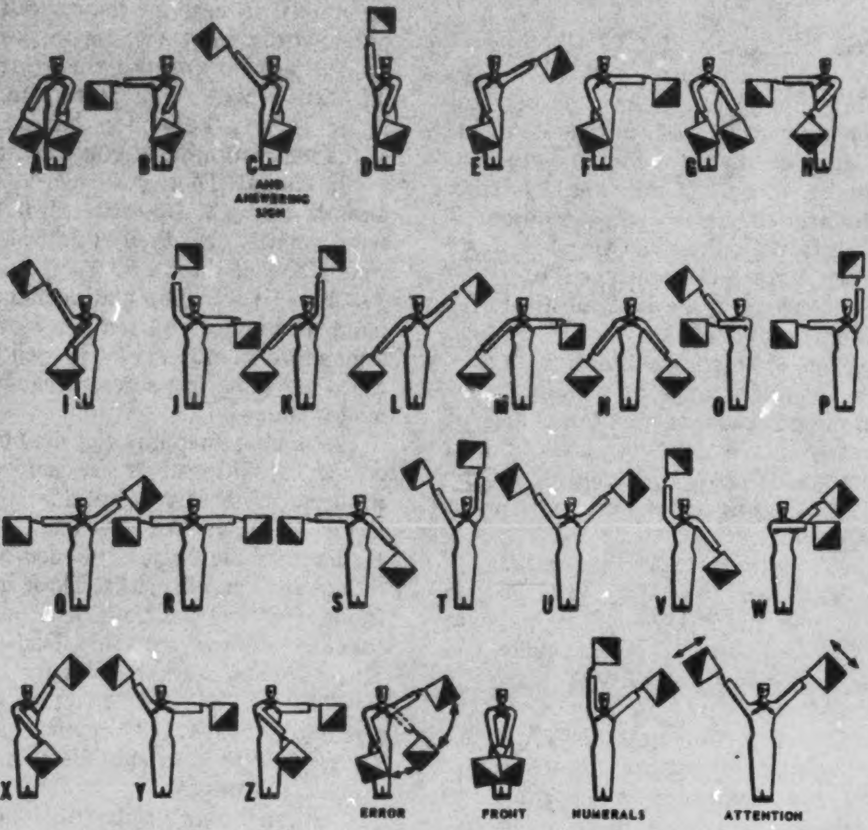
A single semaphore flag may be held in eight correct positions. You can picture these positions easily if you imagine yourself standing inside a circle, like the man in figure 16-5. Notice that the circle is divided into eight parts by equally spaced marks. These marks represent the correct flag positions. Any position between them is sloppy and only leads to confusion. When you practice, move your arms from one position to another by the shortest route possible. Always make your characters in the same plane as your shoulders, and extend your arms to full length.

Although one flag has only eight positions, a large number of conbinations is possible when both flags are used. Of the possible combinations, 28 are used in semaphore communication. There are 26 letters in the alphabet, plus two signs meaning NUMERALS and FRONT.

The FRONT sign (see figure 16-3) is used after you finish a word; it's like the space left between words in ordinary writing. It also is used before and after each call sign, code group, or procedure sign, and between all letters and numerals of a call sign.

The numeral sign is given just before you start transmitting a group of numbers that are to be recorded as numerals and again when the numerals are completed

You'll notice that letters C and E are also used as special signs. The ANSWERING sign is the same as letter C. The ERROR sign consists of letter E,



17.18

Figure 16-3.—Semaphore alphabet and special signals.

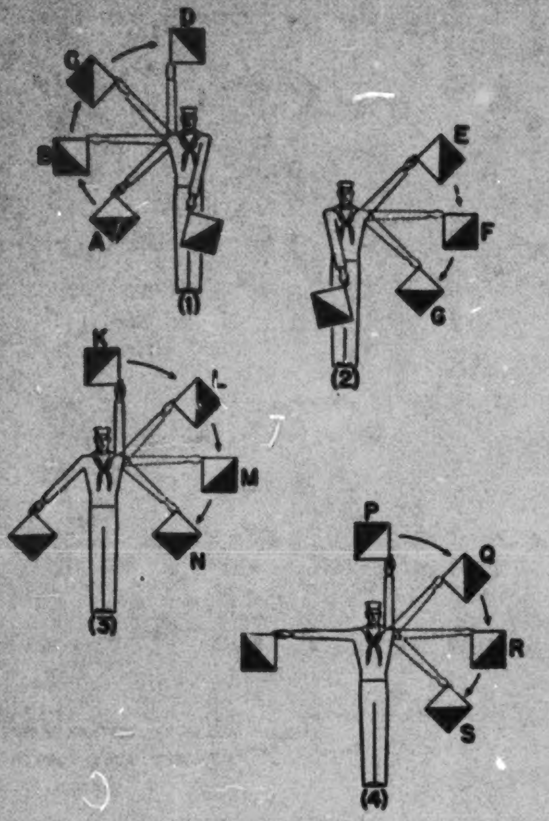
made several times. The ATTENTION sign is made by waving both flags from the horizontal to the overhead position.

The semaphore alphabet isn't at all hard to learn. The speed with which you learn it depends on how consistently you practice. After you master the fundamental positions and can place the flags in these positions quickly and surely, begin practicing the letters as you see them in figure 16-3.

Remember that the positions shown in the illustration are as you would see them if you were the receiver of the transmission—not the sender. Don't try for speed right away. Speed comes after you've thoroughly mastered the alphabet.

The various instructors who teach semaphore in Navy training schools have several different systems, all of which they believe make learning easier. One of the most popular methods is the so-called system of opposites. The object here is to learn the letter indicated by a particular position and then to learn the letter made by exactly the opposite position. If you like this system of learning, you can get some hlep on it as you practice by referring to figure 16-6.

The figure shows that all the positions have opposites—except those for the letters L, D, and R.



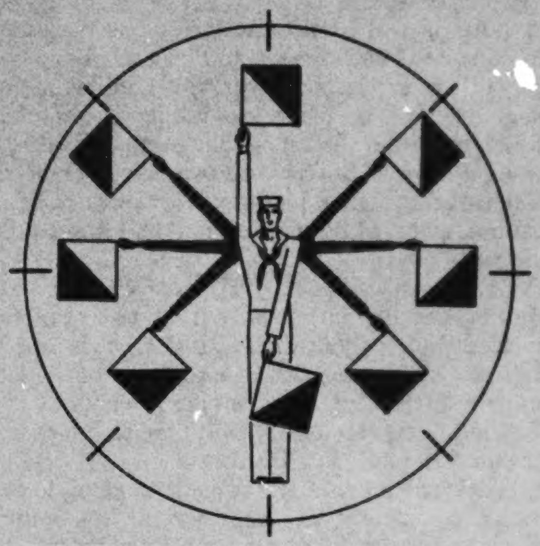
69.119

Figure 16-4.—Position drill.

FLAGHOIST SIGNALING

Flaghoist signaling provides a rapid and accurate system of handling tactical and informational signals of reasonable length during daylight between ships in proximity. In general, a flaghoist signal ensures a more uniform execution of a maneuver than any other visual system.

For signaling by flaghoist, the Navy uses the international alphabet flags and numeral pennants, Navy numeral flags, and special flags and pennants. These groups are shown in figures 16-7 and 16-8. Only the alphabet flags; numeral pennants; FIRST, SECOND, and THIRD substitutes; and CODE/ANSWERING pennant are used in international signaling procedure. Each alphabet flag has the name of the letter it represents, and a numeral flag takes the name of the numeral it represents.



17.19

Figure 16-5.—Semaphore position circle.

Parts of a Flag

Figure 16-9 shows the various flag types and their parts. The fly is the length of the flag, measured from the staff to the outside edge. The hoist is the vertical width of the flag when flying free. The tabling is the double thickness of bunting—taped, bound, and stitched—at the hoist of a flag. The tail line is a short length of halyard attached to the lower part of the tabling carrying the snaphook. It serves as a spacer, separating the flags of a hoist for clearness in reading signals. The snap is a brass releasing hook, attached to the lower end of the tail line or uphaul halyard, which fits into the ring of the next succeeding flag or into the ring of the downhaul halyard. The ring is a brass circle attached to the top of the tabling or to the free end of the downhaul halyard. The ring is the receiver for the snap.

A tackline is a piece of signal halyard (about 6 feet long) with a ring at one end and a snap at the other end. Uses of the tackline are discussed later in this chapter.

How to Read Flaghoists

The flags of a hoist are always read from the top down. When a signal is too long to fit on one halyard—when, in other words, it requires more flags than can be made into a single hoist—the signal must be continued on another halyard. When a signal is broken into two or more hoists, it must be divided at points where there can be a natural space without affecting the meaning of the signal.

A complete signal or group of signals—whether on one hoist or on two or more adjacent hoists flying at the same time—is called a display. When displays of more than one hoist are raised, the separate hoists are run up, one by one, in the correct order. Don't try to run them up simultaneously.

As a general rule, if a signal is too long to be shown completely on three halyards, it's better to make two or more displays from the signal. When two or more displays are used, the heading must be hoisted on a separate halyard and kept flying while successive displays are made.

When two or more hoists are flying, they are read from outboard in, or from forward aft. Figure 16-10 shows how to read a three-hoist display from the top down and from outboard in.

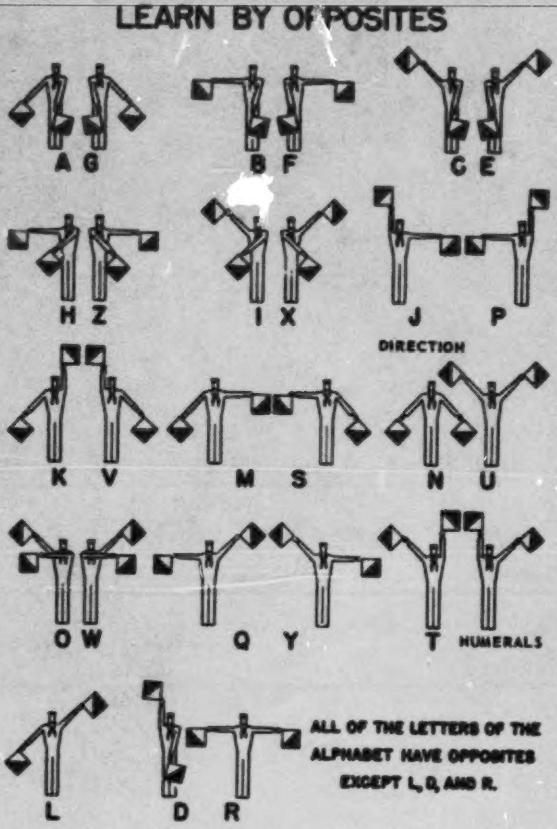
Flags may also be hoisted at the triatic stay. It is a line extending from the foremast to a stack or another mast. Such signals are read from forward aft. A triatic stay is illustrated in figure 16-11. This illustration also shows hoists at two positions on a yardarm.

When signals are hoisted at yardarms of different heights, those at the higher yardarm are read first. When several hoists are displayed simultaneously from different points, they are read in the following order: (1) masthead, (2) triatic stay, (3) starboard yardarm, and (4) port yardarm.

Terms used to describe the status of flaghoists follow.

Close up: A hoist is close up when its top is touching the block at the point of hoist—in other words, when the hoist is up as far as it will go.

At the dip: A hoist is at the dip (or dipped) when it is hoisted three-fourths of the way up toward the point of hoist.



ALL OF THE LETTERS OF THE ALPHABET HAVE OPPOSITES EXCEPT L, D, AND R.

69.120

Figure 16-6.—The system of opposites.

Hauled down: A hoist is hauled down when it is returned to the deck.

Superior position: Any hoist or portion of a hoist that is to be read before another hoist or portion of a hoist is said to be in a superior position.

Comparison of Allied/International Procedure

Allied flaghoist procedure (used in military communications) and international procedure (used in merchant and merchant/military flaghoist communications) differ in several particulars. The following paragraphs explain the procedures and point out the differences.

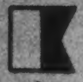
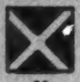
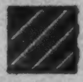
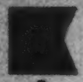
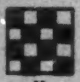
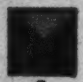
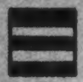
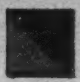
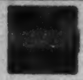
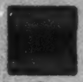
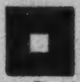
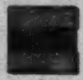
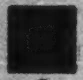
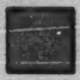
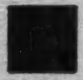
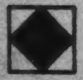
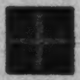
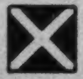
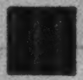
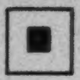
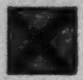
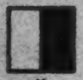
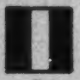
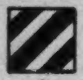
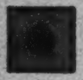
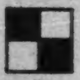
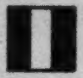
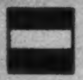
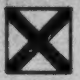
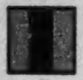
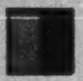
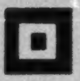
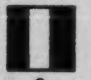
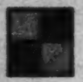
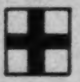
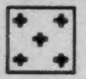
FLAG and NAME	Spoken	Written	FLAG and NAME	Spoken	Written	FLAG and NAME	Spoken	Written
 A	ALFA	A	 M	MIKE	M	 Y	YANKEE	Y
 B	BRAVO	B	 N	NOVEMBER	N	 Z	ZULU	Z
 C	CHARLIE	C	 O	OSCAR	O	 1	ONE	1
 D	DELTA	D	 P	PAPA	P	 2	TWO	2
 E	ECHO	E	 Q	QUEBEC	Q	 3	THREE	3
 F	FOXTROT	F	 R	ROMEO	R	 4	FOUR	4
 G	GOLF	G	 S	SIERRA	S	 5	FIVE	5
 H	HOTEL	H	 T	TANGO	T	 6	SIX	6
 I	INDIA	I	 U	UNIFORM	U	 7	SEVEN	7
 J	JULIETT	J	 V	VICTOR	V	 8	EIGHT	8
 K	KILO	K	 W	WHISKEY	W	 9	NINE	9
 L	LIMA	L	 X	XRAY	X	 0	ZERO	0

Figure 16-7.—Alphabet and numeral flags. C17.67

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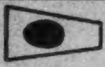
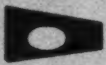
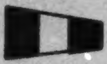
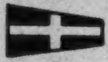
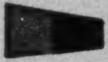
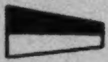
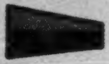
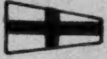
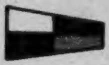
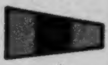
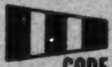
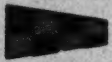
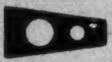
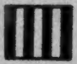
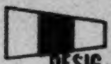
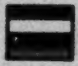
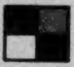
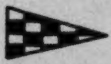
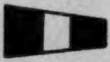
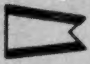
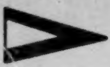
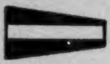
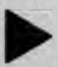
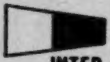
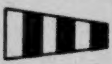
 1	PENNANT ONE	p1
 2	PENNANT TWO	p2
 3	PENNANT THREE	p3
 4	PENNANT FOUR	p4
 5	PENNANT FIVE	p5
 6	PENNANT SIX	p6
 7	PENNANT SEVEN	p7
 8	PENNANT EIGHT	p8
 9	PENNANT NINE	p9
 0	PENNANT ZERO	p0
TACK LINE	TACK	

PENNANT or FLAG	Spoken	Written	PENNANT or FLAG	Spoken	Written
 CODE or ANSWER	CODE or ANSWER	CODE or ANS	 NEGATIVE	NEGAT	NEGAT
SCREEN	SCREEN	SCREEN	PREPARATIVE	PREP	PREP
 CORPEN	CORPEN	CORPEN	 PORT	PORT	PORT
 DESIGNATION	DESIG	DESIG	SPEED	SPEED	SPEED
 DIVISION	DIV	DIV	 SQUADRON	SQUAD	SQUAD
 EMERGENCY	EMERGENCY	EMERG	 STARBOARD	STARBOARD	STBD
 FLOTILLA	FLOT	FLOT	 STATION	STATION	STATION
 FORMATION	FORMATION	FORM	 SUBDIVISION	SUBDIV	SUBDIV
 INTERROGATIVE	INTERROGATIVE	INT	 TURN	TURN	TURN

SUBSTITUTES

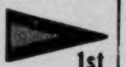
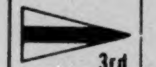
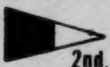
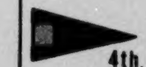
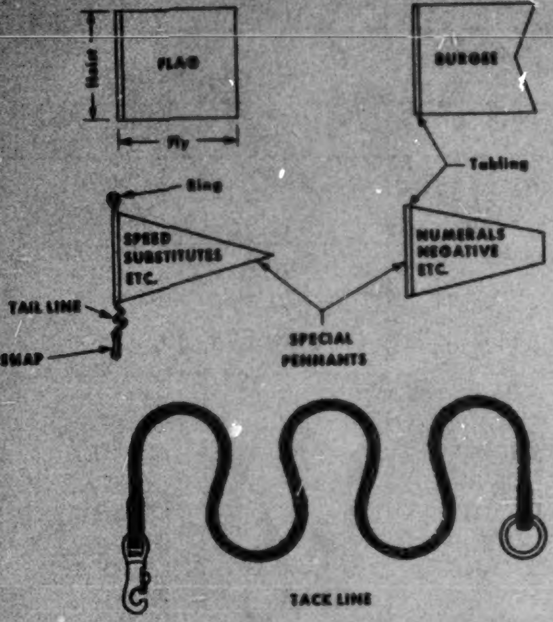
 1st. SUBSTITUTE	FIRST SUB	1st.	 3rd. SUBSTITUTE	THIRD SUB	3rd.
 2nd. SUBSTITUTE	SECOND SUB	2nd.	 4th. SUBSTITUTE	FOURTH SUB	4th.

Figure 16-8.—Numeral pennants, special flags and pennants, and substitutes. C17.68


Hoist
FLAG
Fly
BURGEE
Tabling
Ring
SPEED SUBSTITUTES ETC.
NUMERALS NEGATIVE ETC.
TAIL LINE
SNAP
SPECIAL PENNANTS
TACK LINE

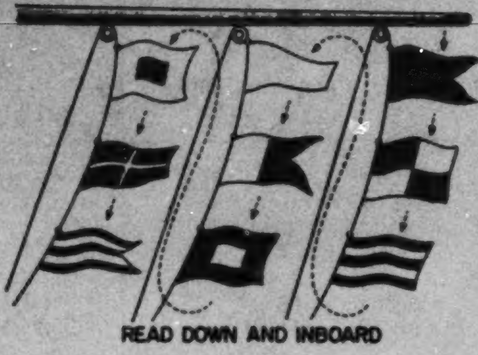
69.121

Figure 16-9.—Parts and types of flags and pennants.

HOW TO CALL–In allied procedure, call signs, address groups, and unit indicators (all discussed later) may be used to establish communications with ships, units, or commands. When the call is used, it is hoisted in a superior position. The call may be omitted under the following circumstances.

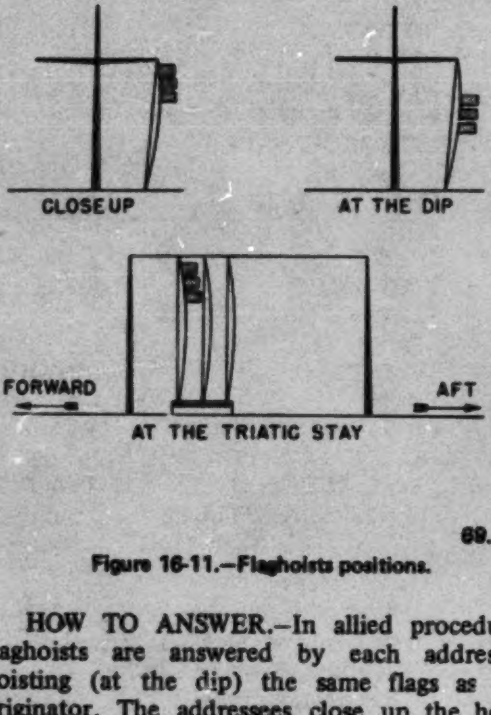
1. By the OTC (SOPA in port) on signals addressed to all ships.
2. By ships addressing OTC, when no relay is required and no confusion will result.
3. By ships originating emergency alarm signals.

In international procedure, the international signal letters of the ship addressed must be hoisted in a position superior to the signal. When no signal letters are hoisted, any signal will be understood as being addressed to all ships within visual signaling distance.


READ DOWN AND INBOARD

69.122

Figure 16-10.—Reading flaghoists.


CLOSE UP
AT THE DIP
FORWARD
AFT
AT THE TRIATIC STAY

69.123

Figure 16-11.—Flaghoists positions.

HOW TO ANSWER.–In allied procedure, flaghoists are answered by each addressee hoisting (at the dip) the same flags as the originator. The addressees close up the hoist when its meaning is understood.

In international procedure, hoists are answered by raising ANSWER to the dip. The answering pennant is put close up when the signal is understood.

Table 16-2.—Transmission of Flags and Pennants

Flag/Pennant	Morse		Semaphore	
	Call sign	Text	Call sign	Text
A-Z	A-Z	ALFA to ZULU[1]	A-Z	ALFA to ZULU[1]
1-0	1-0	ONE to ZERO[1]	ONE to ZERO[1]	
p1-p0	1-0	1 to 0	ONE to ZERO[1]	
ANSWER		ANS		ANS
CODE		CODE		CODE
SCREEN		SCREEN		SCREEN
CORPEN		CORPEN		CORPEN
DESIG		DESIG		DESIG
DIVISION	DIV	DIV	DIV	DIV
EMERGENCY		EMERG		EMERG
FLOTILLA	FLOT	FLOT	FLOT	FLOT
FORMATION		FORM		FORM
INTERROGATIVE		INT		INT
NEGATIVE		NEGAT		NEGAT
PREPARATIVE		PREP		PREP
PORT		PORT		PORT
SPEED		SPEED		SPEED
SQUADRON	SQUAD	SQUAD	SQUAD	SQUAD
STARBOARD		STBD		STBD
STATION		STATION		STATION
SUBDIVISION	SUBDIV	SUBDIV	SUBDIV	SUBDIV
TURN		TURN		TURN
FIRST SUBSTITUTE	First[2]		Not used	
SECOND SUBSTITUTE	Second[2]		Not used	
THIRD SUBSTITUTE	Third[2]		Not used	
FOURTH SUBSTITUTE	Fourth[2]		Not used	

---

[1] At the discretion of the OTC, when conditions and operator's capabilities permit, all of the alphabetical and numeral flags and numeral pennants comprising a signal from ATP 1B, Vol. II may be transmitted as their Morse symbols to expedite signaling.

[2] Substitutes are used only when expediting by flashing light (a flaghoist preceded by a substitute), or when the operating signal meaning "hoist the following signal" is used and a substitute appears as the first flag. The substitute is then transmitted as first, second, third, or fourth, as appropriate.

69.135

SIGNALS NOT UNDERSTOOD.–In allied signaling, the interrogative pennant is used to indicate that the addressee does not understand the meaning of a hoist or that he desires to question its meaning. The originator's hoist is repeated, at the dip, and INT is hoisted close up on an adjacent hoist.

In international procedure, if a receiving ship does not understand the meaning of a signal, she hoists "CODE ZL," signifying "Your signal has been received but not understood," or "CODE ZQ," signifying "Your signal appears incorrectly coded. You should check and repeat the entire signal." If the receiving ship cannot clearly read the signal made to her, she hoists an appropriate signal from the International Code of Signals (Pub No. 102). (NOTE: All signals from 102, when used by naval ships, must be preceded by the CODE pennant.)

USE OF SUBSTITUTES.–Allied procedure specifies that the 1st, 2nd, 3rd, and 4th substitutes repeat the first, second, third, and fourth flag or pennant (respectively), counting down from the top of that hoist. Once a substitute is used, it no longer may be thought of as a substitute. Rather, it is considered the flag or pennant for which it was substituted. When a tackline separates hoist components, it is disregarded in the substitute count. Examples:

T1410 may be hoisted at T 1 4 2nd 0.
161416 may be hoisted as 1 6 1st 4 3rd 2nd.

International procedure differs from the allied usage in that substitutes can only repeat a signal flag of the same class as that immediately preceding it–alphabet flags and numeral pennants comprising the two classes. The code/answering pennant is disregarded in determining which substitutes to use. No substitutes can be used more than once in any hoist. Examples:

JULL may be hoisted as J U L 3rd.
B3CB may be hoisted as B 1st C 2nd.
1000 may be hoisted as 1 0 2nd 3rd.
T1330 may be hoisted as T 1 3 2nd 0.

(Note that in the last example both classes of flags are used. Because the second substitute immediately follows a numeral pennant, under international procedure, it can only repeat a numeral pennant. Actually, pennant 3 is the third flag in the hoist, but the second pennant; therefore, the second substitute is used instead of the third.

Flags and Pennants

In learning the alphabet flags, numeral flags and pennants, and special flags and pennants, practice sketching each flag. Label each one according to its proper color(s). When you feel that you know every flag, ask someone to test you. Ask him to call the flags at random, then you name and describe them. Whenever you are topside, pay particular attention to the flaghoists flying from the various ships close aboard, and check yourself on your ability to recognize and name them.

Flags and pennants used in flaghoist messages are written and spoken as shown in figures 16-7 and 16-8. These flags and pennants are transmitted by international Morse code and semaphore as shown in table 16-2. The tackline is spoken and transmitted TACK and written as a dash (-).

Logging Signals

All flaghoist signals–whether incoming, outgoing, or relayed–must be logged, together with the date, time of receipt (or time of delivery), time of execution, orginator, and addressee(s). The entire signal (but not its meaning) must be recorded exactly as sent or received.

VISUAL PROCEDURE

The discussion just presented on the methods of visual signaling is only the beginning of this specialized field of communication. Once you become acquainted with these methods, the next step is to learn to employ them in the systematic way the Navy prescribes. At first, it may seem difficult, but continually studying the necessary signaling publications will soon provide you the working knowledge needed to carry out this responsibility efficiently on your own.

Many new words and terms must be learned before you can begin to understand visual signaling procedure. Examples of these terms are procedure signs, operating signals, call signs, address groups, originator, addressees, and the like. It is not the purpose of this chapter to cover this material in detail. It is your responsibility as a Quartermaster to look up these items and other applicable material in current signal publications. Complete information on visual communication procedures may be found in the effective edition of ACP 129, Communication Instructions, Visual Signaling Procedures.

For purposes of simplification and brevity, the Navy has established standardized signals, which, in some instances, apply to one or all of the methods of signaling previously discussed. A short coverage of the more important ones is given here.

PROCEDURE SIGNS

The naval procedure signs or prosigns are special signals of one or more letters or characters used to facilitate communication by conveying, in condensed standard form, certain frequently used orders, instructions, requests, and information related to communications. A complete list of prosigns, authorized for use in visual signaling, accompanies this text. An overscore indicates that the letters are to be transmitted as a single character (i.e., without pausing between letters).

Prosign	Meaning
$\overline{\text{AA}}$	Unknown station (flashing light only)
AA	All after
AB	All before
$\overline{\text{AR}}$	End of transmission
$\overline{\text{AS}}$	Wait
B	More to follow
$\overline{\text{BT}}$	Long break
C	Correct
C	Answer sign (semaphore only)
D	Reduce brilliancy or use smaller light
DE	From
EEEEEEEE	Error
F	Do not answer
FM	Originator's sign
G	Repeat back
GR(numeral(s))	Group count
GRNC	Groups not counted
$\overline{\text{HM}}$ (3 times)	Emergency silence sign
II	Separative sign
$\overline{\text{IMI}}$	Repeat
INFO	Information addressee sign
$\overline{\text{INT}}$	Interrogatory
$\overline{\text{IX}}$	Execute to follow
$\overline{\text{IX}}$ (5-second flash)	Executive signal
J	Verify with originator and repeat
K	Invitation to transmit
L	Relay or relayed (flashing light and semaphore only)
NEGAT	Exempted addressee sign (flaghoist only)
NR	Number

Prosign	Meaning
O	Immediate
$\overline{\text{OL}}$	Show steady dim light
P	Priority (precedence)
$\overline{\text{PT}}$	Call sign follows (flashing light and semaphore only)
R	Received
R	Routine (precedence)
T	Transmit to
TO	Action addressee sign
W	Information addressee sign (flaghoist only)
WA	Word after
WB	Word before
XMT	Exempted addressee sign
Z	Flash (precedence)

PUNCTUATION

Punctuation should be used when it is essential to the sense of a message. When no signal equivalent for a punctuation mark exists, the mark may be abbreviated or spelled out. Punctuation marks authorized for visual communication are indicated in the accompanying list.

Name	Morse	Semaphore	Symbol
Colon	---...	$\overline{\text{OS}}$	:
Comma	--..--	$\overline{\text{MIM}}$	,
Hyphen or dash	-....-	$\overline{\text{DU}}$	-
Parenthesis/left	-.--.	$\overline{\text{KN}}$	(
Parenthesis/right	-.--.-	$\overline{\text{KK}}$	)
Period	.-.-.-	$\overline{\text{AAA}}$	.
Question mark	..--..	$\overline{\text{IMI}}$	?
Slant sign	-..-.	$\overline{\text{XE}}$	/

OPERATING SIGNALS

Operating signals (OpSigs) are a concise, standardized code designed for use by communication personnel in the exchange of information incident to traffic handling. Use of operating signals may reduce both the number and the length of transmissions necessary to convey certain information. This code consists of three-letter groups, beginning with the letter Q or Z.

The Q and Z signals—as operating signals sometimes are called—possess no security and must, therefore, be treated as the equivalent of plain language. The Z signals are for use in military communications and should be used when a Z signal of proper meaning is available. The Q signals may be used in military communications when no suitable Z signal exists. Only Q signals may be used in nonmilitary communications.

Some signals may be used as either a statement or a question. Appropriate signals that normally would be interpreted as a statement may be changed to a question by simply preceding the signal with the prosign $\overline{\text{INT}}$ (in military communications) or by using the prosign $\overline{\text{IMI}}$ after the signal (in nonmilitary communications). Following are two examples of message exchanges between the USS Graham County (L6) and the signal tower at NAB, Little Creek (H13). Graham County wants to know whether message 080745Z concerns her.

In example 1 (using plain language), Graham County transmits:

H13 DE L6 DOES MESSAGE 080745Z CONCERN ME K

The signal tower replies:

L6 DE H13 MESSAGE 080745Z NO LONGER CONCERNS YOU K

In example 2 (using operating signal), Graham County transmits:

H13 DE L6 $\overline{\text{INT}}$ ZFK 080745Z K

Signal tower replies:

L6 DE H13 ZFK2 K

The same operating signal (ZFK) was used here as both the question and the answer.

It is obvious that the signal exchange in the second example is shorter and less time-consuming to transmit and receive than the plain language exchange in the first example. Other examples of operating signals, together with complete instructions for their use and interpretation, may be found in the effective edition of ACP 131, Communication Instructions Operating Signals.

CALL SIGNS AND ADDRESS GROUPS

Call signs (not to be confused with the operating signals) are divided into a number of specialized applications. For example, radio call signs are groups of letters, numerals, or combinations of both, which identify radio stations. Other types of calls in use are visual call signs, individual ship calls, unit indicator call signs, visual commander call signs, international call signs, tactical call signs, and many more. Examples of several call signs follow.

Type	Actual Call Sign	Unit Referred To
Radio and international call sign.	NJVF	USS Forrestal
Visual call sign.	R59	USS Forrestal
Visual commander call sign.	SQUAD D	Commander this destroyer squadron.
Special task organization call sign.	3p6	Commander Task Element 6.

Several of the more important call sign books include Call Sign Book for Ships, Visual Call Sign Book, Tactical Call Sign Book, and Task Organization Call Sign Book.

Address groups consist of four-letter groups assigned to activities or commands established to help expedite the transmission and delivery of messages sent by any means. Address groups assigned to our armed forces as well as our allies are listed in ACP 100, Allied Call Signs and Address Group Systems–Instructions and Assignments.

THE MESSAGE

The purpose of the brief discussion just given on visual procedure was to point out to you that there is much more to visual communication than learning the dots and dashes of Morse code, or even learning the meaning of the various signaling flags and pennants. To repeat, visual signaling proficiency requires a thorough study of current publications plus continual practice.

The ultimate aim of learning the methods and procedures of visual signaling is to deliver a message correctly, quickly, and in as brief a form as possible.

The Navy defines (in ACP 121) a message as "any thought or idea expressed briefly in plain or secret language prepared in a form suitable for transmission by any means of communications." A message in any form consists of three main parts: the heading, the text, and the ending procedure. (Refer to table 16-1.)

1. The heading is subdivided into four component parts: the procedure, preamble, address, and prefix. The heading is transmitted at a slower speed than the text, because it may contain many letters and numerals that make it harder to receive.

a. The procedure component contains the call signs of the sender and receiver. Example: NUBP DE NJVF. Here we have NUBP, call sign of the USS Duluth; the prosign DE, meaning "This transmission is from the station whose call sign follows"; and NJVF, the call sign of the USS Forrestal. The call is followed by a prosign giving the transmission instructions if a relay is necessary.

b. The preamble is the component of the heading between the transmission instructions and the address. It contains the precedence, date-time group, and message instructions. The preamble cannot be changed by anyone except the person who originates the message.

c. The address follows the preamble. It is fixed by the originator and must not be altered or changed by any other station. It contains the identity of the originator and the addressee(s), with applicable prosigns.

d. The final component of the heading is the prefix. It may contain the accounting symbol, the group count, and the service message indicator.

2. The text is the main part of the message. The text contains the basic idea or information the originator desires to communicate to the addressee(s). The text cannot be changed by any person other than the originator. It may be in plain language or it may be sent encrypted or encoded. The heading, text, and ending are separated by BREAK ($\overline{\text{BT}}$).

3. Now you know what the heading and the text of a message contain. Only one part remains—the ending procedure, which marks the end of the message. It tells receiving stations to receipt, to wait, to stand by for more messages or for further instructions, or it informs them that a repetition is being made. Often it is the Signalman or Quartermaster who decides what final instructions are to be used in the ending procedures for the message.

The ending sign is the last prosign of every message. It is either K or $\overline{\text{AR}}$, depending on whether a response is required. The ending sign $\overline{\text{AR}}$ means, "This is the end of my transmission to you and no response is required or expected." The ending sign K means, "This is the end of my transmission and a response from you, or station indicated, is necessary."

Prosign K is used only in naval procedure. It is not a prosign in international procedure. When communicating with merchant vessels, prosign $\overline{\text{AR}}$ is used.

SOUND SIGNALING

Whistle and bell signals constitute the principal methods of communicating by sound. Sound signals usually are one-way signals with which the originator is able to broadcast information to ships within hearing distance. The most commonly encountered signals of this type are the whistle and bell signals specified in the Rules of the Road. Some other uses of whistle and bell signals are discussed in this section.

DISTRESS SIGNALS

The continuous sounding of any fog signal apparatus is a signal of distress. Firing a gun or detonating explosive charges at intervals of about 1 minute are also signals of distress. Use of these signals is prohibited for any other reason than as an indication of distress.

FIRE

To indicate a fire aboard a ship, the ship's organization and regulations manual usually provides for ringing the ship's bell. Rapid ringing followed by one, two, or three separate strokes indicates that the fire is forward, amidships, or aft, respectively.

OTHER EMERGENCIES

Whenever a ship hoists an emergency signal, she sounds, in rapid succession, six short blasts on her whistle to attract the attention of other ships in the vicinity. Such signals include the hoists for man overboard, collision, fire, enemy sighting, and all flaghoists preceded by the EMERGENCY pennant.

EXERCISES

In furtherance of the intent of this chapter—to aid you in developing basic visual signaling techniques—a few typical exercise drills are included. Quartermasters are required to transmit and receive—

1. Code groups by flashing light at an approximate speed of 6 groups of 5 characters a minute (6 gpm).

2. Plain language messages by flashing light at an approximate speed of 40 characters a minute (8 wpm).

3. Plain language messages by semaphore at an approximate speed of 40 characters a minute (8 wpm).

The following drills should help increase your transmitting and receiving rates.

INTERNATIONAL MORSE CODE DRILL EXERCISE 1

Practice sending and receiving the international Morse code drill exercise 1 with flashing light until you can send and receive it at the rate of 25 characters a minute.

J G M O H J M O H G O M G M O J G H O M

V R E W B R W B W E A B R E A E B W W A

T H Y N Q Q N Y T Q H Y N Q V T V N Q V

A P D F P D A A D F P P F D A D F P F D

C K L S U K L S U C L S U C K L S K C U

Z X F D I X F D I Z X Z I X D Z F I D F

V J R Y V T L V X V Y R J F Y C V T Z R

9 7 5 3 1 8 6 4 2 0 0 1 3 5 4 2 9 8 6 7

0 7 1 3 3 8 9 7 6 4 2 9 5 8 1 6 0 4 2 5

INTERNATIONAL MORSE CODE DRILL EXERCISE 2

After you are proficient in sending and receiving exercise 1, work on exercise 2 until you can send and receive each mark of punctuation at the rate of 25 per minute.

' : , - ( ) . ? " / / " ? .) (- , : '

/ ' " . ? :) , - (/ ' " . / :) , - (

' : , - ( ) . ? " / / " ? .) (- , : '

(- ,) : / . " ' / (- ,) : ? . " ' ?

SEMAPHORE DRILL EXERCISE 1

You should now be able to send each letter of the alphabet easily and without hesitation, so you are ready to start sending groups. Start with semaphore drill exercise 1. Do not try for speed; that will come later.

EGMGH RILCO MUCVX LXDIR

ZKOEW MGQEH WFKZO SMGDH

QFWRK LUIVN CIJQV HJEGO

SPJSY BTSPA PAYTD SCIVN

MGQEH LSMYZ FXNUV BTSPA

SEMAPHORE DRILL EXERCISE 2

Practice sending and receiving semaphore drill exercise 2, using the FRONT sign and SPACE sign.

KFUGI AGZMZ LORPZ RAZLG ISMFJ

HOKZV CKEXQ BXQFY FOTUB WBPYQ

AYNDS NAVTR KWUGS ZECQK HCVTE

LMPIB CTEVH NGJIE VORSZ HWDNV

XQTCW RAHED GLKUN JROAX DJXQM

INTERNATIONAL MORSE CODE DRILL EXERCISE 3

Now that you have gained proficiency in transmitting and receiving letters, numerals, and punctuation, practice exercise 3—a letter/numeral/ punctuation combination—until you can send and receive each character at the rate of 25 per minute.

J 9 ' 6 7 : M 0 5 3 , - H 1 (J 8) M 6

. V 9 / G 7 : R 7 - H B R W Q 1 3 " - ?

0 A D F 7 ' ' V U R S) W Q F C 6 D Z :

V A 0 2 3 (/ C K L S " . 9 7 1 3 V J R

R Z T 7 6 8 ' : , F 7 (? - X C Q L Y P

A 1 C ' Q 2 B ' 0 J 3 E , Y K / D ? R B

E R 6 D Z N B J) F 8) A 0 P Q I K . F

P 9 B / N 1 " H 8 ? M T 2 G T 7 M . V A

H) 1 3 S 6 F S (P 4 - C Q , C X K L G

5 : 0 ' W (6) " U 0 W 7 . 8 0 " K B X

W 4 - 5 Z Y V L Q " Z : U F C Y / ? 9 U

INTERNATIONAL MORSE CODE DRILL EXERCISE 4

Practice sending and receiving this exercise until you can send and receive it at the rate of 6 groups a minute without error.

LABAM REDUP HOVEM PRTEW QUIPS PIMNB
GHKJL TYRYU DSLKI YTIPO MUJYT QPWOI
EURYT LAKSH DHFGM ZNXBC VYGHE QMWNE
RNTBY UVICP FHZLA QAZPL MXKCS WIEJM
DCRUH FVTBY GIVEN STHCM ASHEN RYDAG

SEMAPHORE EXERCISE 3

Practice sending and receiving semaphore exercise 3 by semaphore until you can send and receive at the rate of 20 groups a minute.

BQIZF ZGUZT BHMGV NBQIZ
HTEPD NKOYJ FAGLT RSKTB
MYKUC CEUDV ZQUHP MOWQE
GOJSX QTYOA SCIQR IPCGQ
VAWLR IKEJW XOJBV NRXPM
DAFJN JPUSL RWAVL XOGJS
LYSHV FDCXR TEHDP KUMYC

SEMAPHORE EXERCISE 4

Practice sending and receiving semaphore exercise 4 until you can send and receive it without error in 4 minutes.

TQYJR MGLFU MFIZE DLFMS

VDKPD BIZOE AHSKD TPCNV

WSAXH HNXAW JCTGL ACGBU
ECOZB DSPKV BUONX HKQWZ

UIFLM RCJYT PWVRY EXJYR

LCPND MKSGU NEDRX PJBPC

QEISV TLFVR WMAOC QKDSA

MAWHR EXHDN FQLPK ULMZI

FZTUO IWOCY SYBVJ ETNWF

XBGKY QPBZJ TIGZU VOGXH

ETKDU LFISG RW[illegible]HJ VMQNX

LAQVG MERWH NCXSI OCTYJ
PIGWU HZJOQ VBNRC AXKSD

WBRMH XCSNI YTDOQ ZEUPK

NCSWD OEYVE PGZUH QIBUJ
NEXVF ODWYH PGZUJ QIATL

APPENDIX I

GLOSSARY

ACCELEROMETER: An instrument used to measure changes in velocity.

AFTER TRUCK: The highest part of the after mast.

AGROUND: When any part of a ship is resting on the bottom. A ship runs aground or goes aground.

AIR ALMANAC: A periodical publication of astronomical data, designed primarily for air navigation.

ALTOCUMULUS: A cloud layer (or patches) within the middle level (mean height 6,500-20,000 ft.), composed of rather flattened globular masses.

ALTOSTRATUS: A sheet of gray or bluish cloud within the middle level (mean height 6,500-20,000 ft.)

ANCHOR BALL: A black circular shape hoisted to indicate that the ship is anchored.

ANCHORED: Made fast to the bottom by an anchor.

ANGLE: The inclination to each other of two intersecting lines, measured by the arc of a circle intercepted between the two lines forming the angle, the center of the circle being the point of intersection.

APPARENT TIME: Time based upon the rotation of the Earth relative to the apparent (true) sun.

ARC: Part of a curved line, as a circle. The graduated scale of an instrument for measuring angles, as a marine sextant.

ATMOSPHERE: The envelope of air surrounding the Earth or other celestial body.

AZIMUTH: The horizontal direction of a celestial point from a terrestrial point. It is usually measured from 000° at the reference direction clockwise through 360°.

BAROMETER: An instrument for measuring atmospheric pressure.

BASE LINE: The line between two transmitters operating together to provide a line of position, as in loran.

BEARING: The horizontal direction of one terrestrial point from another. It is usually measured from 000° at the reference direction clockwise through 360°.

BEARING CIRCLE: A ring designed to fit snugly over a compass or compass repeater, and provided with vanes for observing compass bearings.

BEARING CURSOR: A mechanical or electronic bearing line of a plan-position indicator type of display for reading the target bearing.

BEARING RESOLUTION: The minimum angular separation in a horizontal plane between two targets at the same range that will allow an operator to obtain data on either individual target.

BINNACLE: The stand in which a compass is mounted.

BLAST: Signal on a ship's whistle; short, about one second, prolonged, 4-6 seconds, long, 10-12 seconds.

BLINKING: Regular shifting right and left of a loran signal to indicate that the signals are out of synchronization.

BROAD COMMAND PENNANT: Personal command pennant of an officer, not a flag officer.

BUOY: A floating object, other than a lightship, moored or anchored to the bottom as an aid to navigation.

CELESTIAL EQUATOR: The intersection of the celestial sphere and extended plane of the equator.

CELESTIAL NAVIGATION: Navigation with the aid of celestial bodies.

CELESTIAL SPHERE: An imaginary sphere of infinite radius concentric with the Earth, on which all celestial bodies except the Earth are imagined to be provided.

CELSIUS: Temperature based upon a scale in which, under standard atmospheric pressure, water freezes at 0° and boils at 100°.

CHART: A map intended primarily for navigational use.

CHRONOMETER: A timepiece with a nearly constant rate.

CIRROCUMULUS: High clouds (mean lower level above 20,000 ft.) composed of small white flakes or of very small globular masses.

CIRROSTRATUS: Thin, whitish, high clouds (mean lower level above 20,000 ft.).

CIRRUS: Detached high clouds (mean lower level above 20,000 ft.) of delicate and fibrous appearance.

CLOSE ABOARD: Near; within 600 yards for ship, 400 yards for boat.

CLOSEST POINT OF APPROACH: The position of a contact when it reaches its minimum range to own ship.

CLOSE UP: A flag that is all the way up on its halyard.

CLOUD: A visible assemblage of numerous tiny droplets of water or ice crystals formed by condensation of water vapor in the air, with the base above the surface of the Earth.

COAST PILOT: A descriptive book for the use of mariners, containing detailed information about coastal waters, harbor facilities, etc., of an area, particularly along the coasts of the United States.

COLORS: The national flag. The ceremony of raising the flag at 0800 and lowering it at sunset aboard a ship not underway, or at a shore station.

COMMISSION PENNANT: Narrow red, white, and blue pennant with seven stars, flown at the main truck of a ship in commission.

COMPASS: An instrument for determining courses steered and bearings, by indicating the magnetic or true north and the ship's head.

COMPASS HEADING: A heading relative to compass north.

COMPASS POINTS: The 32 divisions of a compass, at intervals of 11-1/4°.

COMPUTED ALTITUDE: Altitude of the center of a celestial body above the celestial horizon at a given time and place, as determined by computation, table, mechanical device, or graphics.

CONSOL: An electronic navigational system providing a number of rotating equisignal zones that permit determination of bearings from a transmitting station by counting a series of dots and dashes and referring to a table or special chart.

CONTOUR: A line connecting points of equal elevation or equal depth.

CUMULONIMBUS: A massive cloud with great vertical development, the summits of which rise in the form of mountains or towers, the upper parts often spreading out in the form of an anvil.

CUMULUS: A dense cloud with vertical development, having a horizontal base and dome-shaped upper surface, exhibiting protuberances.

CURRENT: Water in essentially horizontal motion. A hypothetical horizontal motion of such set and drift as to account for the difference between a dead-reckoning position and a fix at the same time.

DAYBEACON: An unlighted beacon.

DEAD RECKONING: Determination of position by advancing a previous position for courses and distances.

DECCA: An electronic navigational system by which hyperbolic lines of position are determined by measuring the phase difference of synchronized continuous wave signals.

DECLINATION: Angular distance north or south of the celestial equator and a point on the celestial sphere, measured northward or southward from the celestial equator through 90°, and labeled N or S to indicate the direction of measurement.

DEGAUSSING: Neutralization of the strength of the magnetic field of a vessel, by means of suitably arranged electric coils permanently installed in the vessel.

DEGREE: A unit of circular measure equal to 1/360th of a circle.

DEPTH: Vertical distance from a given water level to the bottom.

DEPTH OF WATER: The vertical distance from the surface of the water to the bottom.

DEPTH-SOUNDING SONAR: A direct reading device for determining the depth of water in fathoms or other units by reflecting sonic or ultrasonic waves from the ocean bottom.

DEVIATION: The angle between the magnetic meridian and the axis of a compass card, expressed in degrees east or west to indicate the direction in which the northern end of the compass card is offset from magnetic north.

DEW POINT: The temperature to which air must be cooled at constant pressure and constant water vapor content to reach saturation.

DIP: Lowering a flag part way in salute or in answer, and hoisting it again. A flag is "at the dip" when it is flown at about two-thirds the height of the halyards.

DIP CORRECTION: That correction to sextant altitude due to dip of the horizon. Also called HEIGHT OF EYE CORRECTION.

DIRECTION OF RELATIVE MOVEMENT: The direction of motion relative to a reference point, itself usually in motion.

DIURNAL: Having a period of, occuring in, or related to a day.

DIVIDERS: An instrument consisting in its simple form of two pointed legs joined by a pivot, and used principally for measuring distances or coordinates.

DOPPLER: The observed change of frequency of a wave caused by a time rate of change of the effective distance traveled by the wave between the source and the point of observation.

DOUBLING THE ANGLE ON THE BOW: A method of obtaining a running fix by measuring the distance a craft travels while the relative bearing (right or left) of a fixed object doubles. The distance from the object at the time of the second bearing is equal to the run between bearings, neglecting drift.

DRESSING LINES: The lines used in dressing ship.

DRESSING SHIP: A display of national colors at all mastheads and the flagstaff. (Full dressing ship requires in addition a rainbow of flags from bow to stern over the mastheads.)

DRIFT: The leeway of a vessel or amount of set of a tide or current; the spare end of a rope.

EBB: Tidal current moving away from land or down a tidal stream.

ELECTROMAGNETIC: Having both magnetic and electric properties.

ELECTRONIC NAVIGATION: Navigation by means of electronic equipment.

EQUATOR: The primary great circle of the Earth, or a similar body, perpendicular to the polar axis.

ESTIMATED POSITION: The most probable position of a craft determined from incomplete data or data of questionable accuracy.

FAHRENHEIT TEMPERATURE: Temperature based upon a scale in which, under standard atmospheric pressure, water freezes at 32° and boils at 212°.

FATHOM: A unit of length equal to 6 feet.

FIX: A relatively accurate position determined without reference to any former position.

FLAGHOIST: A display of flags used to indicate a signal or a group of signals.

FLAGSTAFF: A small vertical spar at the stern on which the ensign is hoisted.

FLOOD TIDE: Tide rising or flowing toward land.

FOG: A visible assemblage of numerous tiny droplets of water, or ice crystals formed by condensation of water vapor in the air, with the base at the surface of the Earth.

FORETRUCK: The highest point of the forward mast.

FRONT: The intersection of a frontal surface and a horizontal plane.

GAFF: A small spar abaft the mainmast from which the national ensign is flown when the ship is underway.

GEOGRAPHICAL POSITION: That point on the Earth at which a given celestial body is in the zenith at a specified time. Any position on the Earth defined by means of its geographical coordinates.

GNOMONIC PROJECTION: A map projection in which points on the surface of a sphere or spheroid, such as the Earth, are conceived as projected by radials from the center to a tangent plane.

GREAT CIRCLE: The intersection of a sphere and a plane through its center.

GREENWICH HOUR ANGLE: Local hour angle at the Greenwich meridian; angular distance west of the Greenwich celestial meridian; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the Greenwich celestial meridian and the hour circle of a point on the celestial sphere, measured westward from the Greenwich celestial meridian through 360°.

GREENWICH MEAN TIME: Local mean time at the Greenwich meridian; the arc of the celestial equator, or the angle at the celestial pole, between the lower branch of the Greenwich celestial meridian and the hour circle of the mean sun, measured westward from the lower branch of the Greenwich celestial meridian through 24 hours; Greenwich hour angle of the mean sun, expressed in time units, plus 12 hours.

GROUND WAVE: That portion of a radio wave in proximity to and affected by the ground, being somewhat refracted by the lower atmosphere and diffracted by the surface of the Earth.

GUN SALUTE: Blank shots fired to honor a dignitary or in celebration.

GYROCOMPASS: A compass having one or more gyroscopes as the directive element, and tending to indicate true north.

GYRO REPEATER: That part of a remote indicating gyrocompass system which repeats at a distance the indications of the master gyrocompass.

HALFMAST: To fly a flag halfway up the mast, as a sign of mourning.

HAUL DOWN: A term used as directive to execute a flaghoist by lowering it.

HONORS AND CEREMONIES: A collective term: official guards, bands, salutes, and other activities that honor the colors, celebrate a holiday, or greet a distinguished guest or officer.

HUMIDITY: The amount of water vapor in the air.

HYPERBOLA: A curve that is the locus of points having a constant difference of distance from two fixed points.

HYPERBOLIC NAVIGATION SYSTEM: A method of radionavigation (e.g., loran) in which pulses transmitted by two ground stations are received by an aircraft or ship.

INDEX CORRECTION: That correction due to index error.

INDICATOR: A device or apparatus, usually partly or wholly automatic, for indicating something.

INERTIAL NAVIGATION SYSTEM (SINS): System designed to guide a ship by a device independent of outside information, using the inertial properties of gyroscopes.

INLAND RULES: Rules of the nautical road that are applicable in most inland U.S. waters.

INTERNATIONAL RULES: Rules of the nautical road made effective by agreement of the major maritime powers for use on high seas and most inland waters of the world, except the U.S.

INTERPOLATION: The process of finding a value between two known values on a chart or graph.

IONOSPHERE: That part of the Earth's atmosphere between the chemopause (at a height of about 50 miles) and the ionopause (at about 250 miles).

ISOBARS: Lines connecting points having the same atmospheric pressure reduced to a common datum, usually sea level.

JOOD: Junior officer of the deck. The assistant to the officer of the deck.

KNOT: The unit of speed that is equivalent to one nautical mile (6080 ft per hour); a collective term for hitches and bends.

LATITUDE: Distance north (N) or south (S) of the Equator, expressed in degrees and minutes.

LIGHT CHARACTERISTICS: The sequence and length of light and dark periods and the color or colors by which it is identified.

LIGHTHOUSE: A distinctive structure exhibiting a major light designed to serve as an aid to navigation.

LIGHT LIST: A publication tabulating navigational lights, with their locations, candle powers, characteristics, etc.

LIGHTSHIP: A distinctively marked vessel anchored or moored at a charted point, to serve as an aid to navigation.

LINE OF POSITION: A line indicating a series of possible positions of a ship, as a result of observation or measurement.

LIST OF LIGHTS: A publication containing aid description of every light in the world, not located in the United States or its possessions.

LOCAL APPARENT NOON: The instant at which the apparent (true) sun is over the upper branch of the local meridian.

LOCAL HOUR ANGLE: Angular distance west of the local celestial meridian; the arc of the celestial equator,or the angle at the celestial pole, between the upper branch of the local celestial meridian and the hour circle of a point on the celestial sphere, measured westward from the local celestial meridian through 360°.

LOCAL MEAN TIME: The arc of the celestial equator or the angle at the celestial pole, between the lower branch of the local celestial meridian and the hour circle of the mean sun, measured westward from the lower branch of the local celestial meridian through 24 hours; local hour angle of the mean sun, expressed in time units, plus 12 hours.

LOCUS: All possible positions of a point or curve satisfying stated conditions.

LONGITUDE: Distance east (E) or west (W) of the prime meridian, which runs through Greenwich, England.

LOOKOUT: A man stationed as a visual watch.

LORAN: An electronic navigational system by which hyperbolic lines of position are determined by measuring the difference in the time of reception of synchronized pulse signals from two fixed transmitters.

LUBBER'S LINE: A reference line on any direction-indicating instrument, marking the reading which coincides with the heading.

LUNAR TIME: Time based upon the rotation of the Earth relative to the Moon.

MAINMAST: Second mast aft from the bow.

MAINTRUCK: The highest part of the mainmast.

MANEUVERING BOARD: A polar coordinate plotting sheet devised to facilitate the solution of problems involving relative movement.

MANEUVERING SHIP: A ship the movements of which are *defined relative* to a given ship called the 'reference ship.

MASTER STATION: The governing of two or more synchronized transmitting stations.

MASTHEAD: The top of a mast.

MASTHEAD LIGHT: White 20-point light required by Rules of the Road to be carried on the foremast of a ship.

MEAN TIME: Time based upon the rotation of the Earth relative to the mean sun.

MERCATOR PROJECTION: A conformal cylindrical map projection in which the surface of a sphere or spheroid, such as the Earth, is conceived as developed on a cylinder tangent along the Equator.

MERIDIAN: A north-south reference line, particularly a great circle through the geographic poles of the Earth.

MESSAGE: Any thought briefly stated in plain or secret language in a form suitable for rapid transmission.

METER: The basic unit of length of the metric system, equal to the distance at 0° C between two lines on a standard platinum-iridium bar.

MICROSECOND: One-millionth of a second.

MILLIBARS: A unit of measure of atmospheric pressure.

MINUTE: The sixtieth part of a degree of arc.

MODULATOR: That part of radio equipment which alters the amplitude, frequency, or phase of a radio signal in accordance with speech or a signal, or which regulates the length of a pulse.

MORSE CODE: Dots and dashes used in communications in place of letters, numerals, and punctuation.

MRM: Distance of relative movement. The distance along the relative movement line between any two specified points or time.

NAUTICAL ALMANAC: A periodical publication of astronomical statistics useful to and designed primarily for marine navigation, particularly the American Nautical Almanac, published by the U.S. Naval Observatory.

NAUTICAL ASTRONOMY: Navigational astronomy.

NAUTICAL MILE: A unit of distance used principally in navigation.

NAVIGATION: The process of directing the movement of a craft from one point to another.

NEAP TIDES: The tides occurring near the times of first and last quarter of the Moon, when the range of tide tends to decrease.

NIMBOSTRATUS: A dark, low, shapeless cloud layer (mean upper level below 6,500 ft.) usually nearly uniform; the typical rain cloud.

NOMOGRAM: A diagram showing, to scale, the relationship between several variables in such a manner that the value of one which corresponds to known values of the others can be determined graphically.

NOT UNDER COMMAND: A ship disabled or uncontrollable.

OFFICIAL VISIT: A formal visit of courtesy requiring special honors and ceremonies.

OMEGA: An electronic navigational system.

OSCILLOSCOPE: An instrument for producing a visual representation of oscillations or changes in an electric current.

PARALLAX: The difference in the apparent direction or position of an object when viewed from different points.

PARALLEL: A circle on the surface of the Earth, parallel to the plane of the Equator and connecting all points of equal latitude, or a circle parallel to the primary great circle of a sphere or spheroid.

PASSING HONORS: Honors, except gun salutes, that are rendered by a ship when ships or embarked officials or officers pass close aboard.

PEAK: The topmost end of the gaff, from which the ensign is flown while a ship is underway.

PELORUS: A dumb compass, or a compass card (called a pelorus card) without a directive element, suitably mounted and provided with vanes to permit observation of relative bearings, unless used in conjunction with a compass, to give true or magnetic bearings.

PHONETIC ALPHABET: A system of words which represent each letter of the alphabet.

PILOTING: Navigation involving frequent or continuous determination of position or a line of position relative to geographical points, to a high order of accuracy.

PIPE THE SIDE: A ceremony conducted at the brow of a ship in which sideboys are paraded and the boatswain's pipe is blown.

PLAN POSITION INDICATOR: A radarscope that has a sweep which originates in the center and moves to the outer edge of the scope and presents an overflow of a given area.

PLOTTING SHEET: A blank chart, usually on the Mercator projection, showing only the graticule and a compass rose, so that the plotting sheet can be used for any longitude.

POLAR DISTANCE: Angular distance from a celestial pole.

POSITION: A point defined by stated or implied coordinates, particularly one on the surface of the Earth.

PRESSURE: Force per unit area. The pressure exerted by the weight of the Earth's atmosphere is called atmospheric or, if indicated by a barometer, barometric pressure.

PROLONGED BLAST: A blast on the whistle of from 4 to 6 seconds' duration.

PROPAGATION: A transmission of electromagnetic energy.

PROWORD: Pronounceable words or phrases which have been assigned meanings for the purpose of expediting message handling on radio circuits where procedure is employed.

PSYCHROMETER: A type of hygrometer (an instrument for determining atmospheric humidity) consisting essentially of dry-bulb and wet-bulb thermometers.

PULSE REPETITION RATE: The rate at which recurrent pulses are transmitted, usually expressed in pulses per second.

QUARTERDECK: The portion of the weather deck designated by the commanding officer for official ceremonies.

RADAR: A system of determining distance of an object by measuring the interval of time between transmission of a radio signal and reception of a signal returned as an echo.

RANGE: Two or more objects in line.

RANGE MARKER: A distance marker, as on a radar PPI.

RANGE STROBE: A electronic range marker on a radar PPI.

RECIPROCAL: A direction 180° from a given direction.

REFERENCE SHIP: A ship to which relative movement of other ship is referred.

REFRACTION: The change in direction of motion of a ray of radiant energy as it passes obliquely from one medium into another in which the speed of propagation is different.

RELATIVE BEARING: Bearing relative to heading or to the ship.

RELATIVE MOTION: Apparent motion; relative movement.

RELATIVE MOVEMENT LINE: A line connecting successive positions of a maneuvering ship relative to a reference ship.

RELATIVE PLOT: A plot of the successive positions of a ship relative to a reference point, which is usually in motion.

ROOT MEAN SQUARE: The square root of the arithmetical mean of the squares of a group of numbers.

RUNNING FIX: A position determined by crossing lines of position obtained at different times and advanced or retired to a common time.

SAILING DIRECTIONS: A descriptive book for the use of mariners, containing detailed information of coastal waters, harbor facilities, etc., of an area.

SCALE: The ratio between the linear dimensions of a chart, map, drawing, etc., and the actual dimensions represented.

SEMIDIAMETER: The radius of a closed figure. Half the angle at the observer subtended by the visible disk of a celestial body.

SET: The direction toward which a current flows.

SEXTANT: A double-reflecting instrument for measuring angles, primarily altitudes of celestial bodies.

SHORAN: A precision electronic position fixing system using a pulse transmitter and receiver and two transponder beacons at fixed points.

SIDEREAL HOUR ANGLE: Angular distance west of the vernal equinox; the arc of the celestial equator, or the angle at the celestial pole, between the hour circle of the vernal equinox and the hour circle of a point on the celestial sphere, measured westward from the hour circle of the vernal equinox through 360°.

SIDEREAL TIME: Time based upon the rotation of the Earth relative to the vernal equinox.

SKY WAVE: An indirect radio wave which travels from the transmitting antenna into the sky, where the ionsphere bends it back toward the Earth.

SLACK WATER: The condition when the speed of a tidal current is zero, especially the momentary condition of zero speed when a reversing current changes direction.

SOLAR TIME: Time based upon the rotation of the Earth relative to the Sun.

SOUNDING: Measured or charted depth of water, or the measurement of such depth.

SPEED OF RELATIVE MOVEMENT: Speed relative to a reference point itself usually in motion.

SPRING TIDES: The tides occurring near the times of full moon and new moon, when the range of tide tends to increase.

STADIMETER: An instrument for determining the distance to an object of known height by measuring the angle subtended at the observer by the object.

STAND: The condition at high or low tide when there is no change in the height of the water.

STAR FINDER: A device to facilitate the identification of stars.

STATUTE MILE: A unit of distance equal to 5280 feet.

STRATOCUMULUS: Low clouds (mean upper level below 6550 ft.) composed of a layer or patches of globular masses or rolls.

STRATUS: A low cloud (mean upper level below 6550 ft.) in a uniform layer.

TANGENT: The ratio of the side opposite an acute angle of a plane right triangle to the shorter side adjacent to the same angle. A straight line, curve, or surface touching a curve or surface at one point.

TELESCOPIC ALIDADE: A device used with a gyro repeater for taking bearings.

TEMPERATURE: Intensity or degree of heat. Fahrenheit temperature is based upon a scale in which water freezes at 32° and boils at about 212°.

TERRESTRIAL SPHERE: The Earth.

THERMOMETER: An instrument for measuring temperature.

THREE-ARM PROTRACTOR: An instrument consisting essentially of a circle graduated in degrees, to which is attached one fixed arm and two arms pivoted at the center and provided with clamps so that they can be set at any angle to the fixed arm, within the limits of the instrument.

TIDE: The periodic rise and fall of the surface of oceans, bays, etc., due principally to the gravitational attraction of the Moon and Sun for the rotating Earth.

TIME DIAGRAM: A diagram in which the celestial equator appears as a circle, and celestial meridians and hour circles as radial lines, used to facilitate solution of time problems and others involving arcs of the celestial equator or angles at the pole by indicating relations between various quantities involved.

TRACK: To follow the movements of an object, as by radar or an optical system.

TRANSMITTER: One who or that which transmits or sends anything, particularly a radio transmitter.

TROPICAL CYCLONE: A violent cyclone originating in the tropics.

TWILIGHT: The periods of incomplete darkness following sunset (evening twilight) or preceding sunrise (morning twilight).

UNION JACK: Flag flown at the bow of a ship moored or anchored, consisting of the union of the national flag. Also flown in the boat of a high official and at a yardarm during a general court-martial or court of inquiry.

UPPER BRANCH: That half of a meridian or celestial meridian from pole to pole which passes through a place or its zenith.

VARIATION: The angle between the magnetic and geographical meridians at any place, expressed in degrees east or west to indicate the direction of magnetic north from true north.

VECTOR: A straight line representing both direction and magnitude.

VECTOR DIAGRAM: A diagram of more than one vector drawn to the same scale and reference direction and in correct position relative to each other.

VERNAL EQUINOX: That point of intersection of the eliptical and the celestial equator, occupied by the Sun as it changes from south to north declination on or about March 21.

VISIBILITY: The extreme horizontal distance at which prominent objects can be seen and identified by the unaided eye.

VOICE RADIO: Electronic communications equipment that transmits the speaker's voice through the air on radio waves to an appropriately tuned receiver.

WAVE LENGTH: The distance in the direction of advance between the same phase of successive waves.

WEATHER: The state of the atmosphere as defined by various meteorological elements, such as temperature, pressure, wind speed, direction, humidity, cloudiness, precipitation, etc.

WIND: Moving air, especially a mass of air having a common direction of motion.

YARDARM: The port or starboard half of a spar set athwartships across the upper part of a mast.

ZONE TIME: The local mean time of a reference or zone meridian whose time is kept throughout a designated zone.

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QUARTERMASTER 3 & 2

NAVEDTRA 10149-F

Prepared by the Naval Education and Training Program Development
Center, Pensacola, Florida

Your NRCC contains a set of assignments and self-scoring answer sheets (packaged separately). The Rate Training Manual, Quartermaster 3&2, NAVEDTRA 10149-F, is your textbook for the NRCC. If an errata sheet comes with the NRCC, make all indicated changes or corrections. Do not change or correct the textbook or assignments in any other way.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

Study the textbook pages given at the beginning of each assignment before trying to answer the items. Pay attention to tables and illustrations as they contain a lot of information. Making your own drawings can help you understand the subject matter. Also, read the learning objectives that precede the sets of items. The learning objectives and items are based on the subject matter or study material in the textbook. The objectives tell you what you should be able to do by studying assigned textual material and answering the items.

At this point you should be ready to answer the items in the assignment. Read each item carefully. Select the BEST ANSWER for each item, consulting your textbook when necessary. Be sure to select the BEST ANSWER from the subject matter in the textbook. You may discuss difficult points in the course with others. However, the answer you select must be your own. Use only the self-scoring answer sheet designated for your assignment. Follow the scoring directions given on the answer sheet itself and elsewhere in this course.

Your NRCC will be administered by your command or, in the case of small commands, by the Naval Education and Training Program Development Center. No matter who administers your course you can complete it successfully by earning grades that average 3.2 or higher. If you are on active duty, the average of your grades in all assignments must be at least 3.2. If you are NOT on active duty, the average of your grades in all assignments of each creditable unit must be at least 3.2. The unit breakdown of the course, if any, is shown later under Naval Reserve Retirement Credit.

WHEN YOUR COURSE IS ADMINISTERED BY LOCAL COMMAND

As soon as you have finished an assignment, submit the completed self-scoring answer sheet to the officer designated to administer it. He will check the accuracy of your score and discuss with you the items that you do not understand. You may wish to record your score on the assignment itself since the self-scoring answer sheet is not returned.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

Although you complete the course successfully, the Naval Education and Training Program Development Center will not issue you a letter of satisfactory completion. Your command will make a note in your service record, giving you credit for your work.

WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

After finishing an assignment, go on to the next. Retain each completed self-scoring answer sheet until you finish all the assignments in a unit (or in the course if it is not divided into units). Using the envelopes provided, mail your self-scored answer sheets to the Naval Education and Training Program Development Center where the scores will be verified and recorded.

Make sure all blanks at the top of each answer sheet are filled in. Unless you furnish all the information required, it will be impossible to give you credit for your work. You may wish to record your scores on the assignments since the self-scoring answer sheets are not returned.

The Naval Education and Training Program Development Center will issue a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course-completion letter, follow the directions given on the course-completion form in the back of this NRCC.

You may keep the textbook and assignments for this course. Return them only in the event you disenroll from the course or otherwise fail to complete the course. Directions for returning the textbook and assignments are given on the book-return form in the back of this NRCC.

PREPARING FOR YOUR ADVANCEMENT EXAMINATION

Your examination for advancement is based on the Manual of Navy Enlisted Manpower and Personnel Classification and Occupational Standards (NAVPERS 18068-D). The sources of questions in this examination are given in the Bibliography for Advancement Study (NAVEDTRA 10052). Since your NRCC and textbook are among the sources listed in this bibliography, be sure to study both in preparing to take your advancement examination. The standards for your rating may have changed since your course and textbook were printed, so refer to the latest editions of NAVPERS 18068-D and NAVEDTRA 10052.

NAVAL RESERVE RETIREMENT CREDIT

The course is evaluated at 22 Naval Reserve retirement points, which will be credited as follows: 12 points upon completion of Assignments 1 thru 6; 10 points upon completion of Assignments 7 thru 11. These points are creditable to personnel eligible to receive them under current directives governing the retirement of Naval Reserve personnel. Credit cannot be given again for this course if the student has previously received credit for completion of another Quartermaster 3&2 NRCC or ECC.

COURSE OBJECTIVE

Upon completion of this course you will demonstrate knowledge of the phases of watchstanding, log keeping, honors and ceremonies, and etc. You will have a basic knowledge of piloting, time, rules of the road, navigational aids, and electronic and celestial navigation.

While working on this nonresident career course, you may refer freely to the text. You may seek advice and instruction from others on problems arising in the course, but the solutions submitted must be the result of your own work and decisions. You are prohibited from referring to or copying the solutions of others, or giving completed solutions to anyone else taking the same course.

Naval nonresident career courses may include a variety of items -- multiple-choice, true-false, matching, etc. The items are not grouped by type; regardless of type, they are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Some courses use many types of items, others only a few. The student can readily identify the type of each item (and the action required of him) through inspection of the samples given below.

MULTIPLE-CHOICE ITEMS

Each item contains several alternatives, one of which provides the best answer to the item. Select the best alternative and erase the appropriate box on the answer sheet.

SAMPLE

s-1. The first person to be appointed Secretary of Defense under the National Security Act of 1947 was
1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

The erasure of a correct answer is indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-1	■	C	■	■	

TRUE-FALSE ITEMS

Determine if the statement is true or false. If any part of the statement is false the statement is to be considered false. Erase the appropriate box on the answer sheet as indicated below.

SAMPLE

s-2. Any naval officer is authorized to correspond officially with a bureau of the Navy Department without his commanding officer's endorsement.

The erasure of a correct answer is also indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-2	■	CC	■	■	

MATCHING ITEMS

Each set of items consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Specific instructions are given with each set of items. Select the numbers identifying the answers and erase the appropriate boxes on the answer sheet.

SAMPLE

In items s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions.

A. Officers	B. Departments
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Assistant for Disbursing	3. Supply Department
s-6. Communications Officer	

The erasure of a correct answer is indicated in this way on the answer sheet:

	1 T	2 F	3	4	
s-3	■	C	■	■	
s-4	C	■	■	■	
s-5	■	■	C	■	
s-6	C	■	■	■	

How To Score Your Immediate Knowledge of Results (IKOR) Answer Sheets

	1 T	2 F	3	4	
1	■	C	6	■	1
2	C	9	■	9	2
3	■	■	C	■	
4	CC	12	■	■	1

Total the number of incorrect erasures (those that show page numbers) for each item and place in the blank space at the end of each item.

Sample only

Number of boxes erased incorrectly	0-2	3-7	8-
Your score	4.0	3.9	3.8

Now TOTAL the column(s) of incorrect erasures and find your score in the Table at the bottom of EACH answer sheet.

NOTICE: If, on erasing, a page number appears, review text (starting on that page) and erase again until "C", "CC", or "CCC" appears. For courses administered by the Center, the maximum number of points (or incorrect erasures) will be deducted from each item which does NOT have a "C", "CC", or "CCC" uncovered (i.e., 3 pts. for four choice items, 2 pts. for three choice items, and 1 pt. for T/F items).

Assignment 1

The Quartermaster; Watches; Honors and Ceremonies

Textbook, NAVEDTRA 10149-F: Pages 1-33

Learning Objective: Locate and select material to study for rate advancement.

1-1. The Quartermaster rating is identified as a
   1. general rating
   2. service rating
   3. emergency rating
   4. general service rating

1-2. Realizing that, as a petty officer, you will have increased responsibilities of both a practical and a professional nature, in which of the following publications would you find information on practical aspects of leadership?
   1. Navy Department General Order 21
   2. Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068-D
   3. Military Requirements for Petty Officer 3&2, NAVEDTRA 10056
   4. Bibliography for Advancement Study, NAVEDTRA 10052

1-3. Your ability to perform various tasks in your rate by demonstrations will be checked off on what form?
   1. NAVEDTRA 1414/1
   2. NAVEDTRA 602
   3. NAVEDTRA 10061
   4. NAVEDTRA 10052

1-4. Which of
to qualify
   1. Have re
   2. Demonst
   perform
   NAVEDTR
   3. Be reco
   ing off
   4. All of

1-5. Which of t
determine
rate?
   1. Advance
   2. Perform
   3. Number
   in a gi
   4. All of

1-6. Military/L
are admini
determined
   1. Chief o
   2. Bureau
   3. your co
   4. Chief o
   Trainin

1-7. How many q
the Navywi
tions for
and E-5?
   1. 200
   2. 175
   3. 150
   4. 125

ignment 1

Ceremonies

3

---

i-

r,

a

21

-

ds,

y

1-4. Which of the following is necessary to qualify for advancement?
1. Have required time in pay grade
2. Demonstrated the ability to perform all requirements in NAVEDTRA 1414.1
3. Be recommended by your commanding officer
4. All of the above

1-5. Which of the following factors determine who will be advanced in rate?
1. Advancement examination score
2. Performance marks
3. Number of vacancies to be filled in a given rate
4. All of the above

1-6. Military/Leadership Examinations are administered on a schedule determined by
1. Chief of Naval Operations
2. Bureau of Naval Personnel
3. your commanding officer
4. Chief of Naval Education and Training

1-7. How many questions are there on the Navywide Occupational Examinations for the pay grades of E-4 and E-5?
1. 200
2. 175
3. 150
4. 125

1-8. You are being transferred; to avoid having to requalify in the practical factors that you have already completed, you should ensure that your service record contains an up-to-date
1. NAVEDTRA 602 Form
2. NAVEDTRA 703 Form
3. NAVEDTRA 1052 Form
4. NAVEDTRA 1414/1 Form

1-9. In what publication would you find changes to the Records of Practical Factors?
1. NAVEDTRA 10061
2. NAVEDTRA 10052
3. NAVPERS 18068
4. NAVEDTRA 10056

1-10. You are preparing to take the written examinstion for advancement to QM2. Which references listed in Bibliography for Advancement Study, NAVEDTRA 10052, should you study?
1. Only the asterisk-marked publications for QM2
2. The asterisk-marked publications for QM3 and all references listed for QM2
3. Only the asterisk-marked publications for both QM3 and 2 rates
4. All asterisk-marked and nonmarked publications for both QM3 and 2 rates

1-11. How many general types of rate training manuals are there?
1. 5
2. 4
3. 3
4. 2

1-12. Which of the following lists all current training manuals and nonresident career courses?
1. NAVEDTRA 18068
2. NAVEDTRA 10052
3. NAVEDTRA 10056
4. NAVEDTRA 10061

1-13. Which of the following publications lists training films that may be helpful in advancement?
1. NAVPERS 18068
2. NAVAIR 10-1-777
3. NAVEDTRA 10052
4. NAVSUP-2002

Learning Objective: Describe duties of the quartermaster of the watch underway.

1-14. When is the quartermaster of the watch designated the enlisted supervisor of the watch?
1. At all times on all ships
2. Only on large ships during general quarters
3. At any time except during general quarters
4. On all ships during general quarters

1-15. When should you report to the OOD that you have relieved the watch?
1. After you have received any special information from the man you are relieving
2. After you have reviewed the night order book
3. After you have reviewed the deck log
4. After completing all of the above

1-16. Which of the following personnel serves as the OOD's assistant?
1. The navigator
2. The leading Operations Specialist
3. The quartermaster of the watch
4. The executive officer

1-17. If while on duty as quartermaster of the watch you see that the ship is off course, you should
1. report this fact to the navigator
2. correct the steersman
3. take over the helm
4. report this fact to the OOD

1-18. As a Quartermaster you will have to carry out all of the following actions except
1. reading the indicators in the wheelhouse
2. solving basic problems with the maneuvering board
3. adjusting the gyrocompass
4. identifying ship's lights

1-19. If you have the morning watch, at what time should you relieve the man having the preceding watch?
1. 0345
2. 0400
3. 0745
4. 0800

1-20. Where do you find the captain's standing orders to the watch?
1. Quartermaster's notebook
2. Captain's night order book
3. Rough deck log
4. Morning call book

1-21. You are required, as a quartermaster of the watch, to read current orders that apply to your watch. Before you read these orders, make sure that
1. the date indicated on them is current
2. all watch personnel initial them
3. the Quartermaster you are relieving has initialed them
4. CIC has a copy of them

Learning Objective: Describe duties of the quartermaster of the watch in port.

1-22. Who is responsible for ensuring the proper handling of absentee pennants?
1. BMOW
2. QMOW
3. Messenger
4. Duty Signalman

1-23. The purpose of the drift lead is to indicate
1. depth
2. drag
3. speed
4. course

1-24. When at anchor, you must report any changes of bearing other than those caused by swing to the
1. officer of the deck
2. captain
3. executive officer
4. navigator

1-25. A second anchor will be dropped, right after you have reported to the OOD that the ship is dragging anchor, if your ship is located
1. near shoal water
2. near a lee shore
3. in a crowded anchorage
4. in any of the above circumstances

1-26. Your ship is moored with two anchors, under which of the following conditions must the quartermaster of the watch keep a record of how the ship swings?
1. The anchor chain is slack
2. The drift lead is out
3. No swivel is being used
4. The anchor is in mud

Learning Objectives: Describe duties of other bridge watches, and be familiar with bridge equipment.

1-27. Who usually operates the engine order telegraph?
1. Boatswain's mate of the watch
2. JOOD
3. Lee helmsman
4. Telephone talker

1-28. Normally, which of the following instruments would not be found on the bridge of a ship?
1. Chronometers
2. Sounding instruments
3. Steering instruments
4. Barometers

1-29. When, if ever, are Quartermasters required to stand routine steersman watches?
1. Every other watch
2. Whenever a special situation so dictates
3. Whenever the steersman changes the watch
4. Never, the steersman always stands routine watches

1-30. Assume that your ship is steaming in formation during the hours of darkness. Which of the following devices could be used by the steersman to locate adjacent ships?
1. The plan position indicator
2. The universal drafting machine
3. The dead-reckoning tracer
4. The binnacle-mounted compass

1-31. As quartermaster of the watch, which of the following preparations for getting underway do you perform?
1. Setting up a drafting machine
2. Testing the helm and rudder
3. Checking the annunciator
4. All of the above

1-32. Before testing any noisemaking equipment, you must obtain permission from the
1. leading Quartermaster
2. OOD
3. CDO
4. commanding officer

● The deck log is the complete daily record which describes events of importance concerning the operation and safety of the ship and which may, at some future time, be of historical or legal importance.

1-33. What information should be recorded in the deck log?
1. Only items pertaining to navigation
2. All orders of the OOD copied word for word
3. Only items dictated by the OOD
4. All important facts relating to the events of each watch

1-34. The remarks sheet of the deck log is filled in by the
1. quartermaster of the watch
2. OOD
3. navigator
4. CO

1-35. Assume that, during your tour of duty as quartermaster of the watch, you observe the OOD order a routine change of your ship's course. When, if ever, would you record this event in the deck log?
1. Never, because routine events are not recorded
2. At the change of the watch
3. Immediately
4. When directed to do so by the OOD

1-36. The navigator will sign the deck log daily and submit it to the commanding officer.

1-37. How often is the deck log (A) approved by the ship's commanding officer and (B) forwarded to the Chief of Naval Operations?
1. (A) daily, (B) daily
2. (A) weekly, (B) weekly
3. (A) monthly, (B) monthly
4. (A) daily, (B) monthly

1-38. The abbreviation "OCE," when used as an entry in the deck log, stands for
1. on course
2. officer contact expected
3. officer commanding the exercise
4. officer conducting the exercise

1-39. Which of the following classes of information are recorded in a deck log?
1. Types and amounts of ammunition expended during firing exercises
2. Time fueling commences in port
3. Names of personnel declared deserters
4. All of the above classes of information

1-40. How should an erroneous entry in the deck log be corrected?
1. Erase it and make the correct entry
2. Thoroughly cross it out, make the correct entry, and initial the correction
3. Draw a single line through it, make the correct entry, and initial the correction
4. Leave it intact and cancel it by a later entry

1-41. The entry "Underway as before" may be used (if it applies) for any watch except the
1. midwatch
2. morning watch
3. forenoon watch
4. afternoon watch

1-42. When the tactical command of a group of vessels is shifted, each vessel enters in its log the new OTC's
1. ship only
2. ship and command title only
3. ship, rank, and command title only
4. ship, name, rank, and command title

1-43. Watch-to-watch inventories of publications may be destroyed after
1. 30 days
2. 90 days
3. 6 months
4. 1 year

Learning Objective: Describe how to render passing honors properly on appropriate occasions.

1-44. A boat bearing the flag of a naval officer nears your ship. Attention is sounded when the boat comes within a distance from your ship of approximately
1. 400 yds
2. 800 yds
3. 1000 yds
4. 2000 yds

1-45. Manning the rail is part of the passing honors rendered to the
1. President only
2. President and the Vice President only
3. President and the Secretary of State when acting as a special representative of the President
4. President, Vice President, and Secretary of State when acting as a special representative of the President

1-46. Which of the following officials rates ruffles and flourishes during passing ceremonies between ships?
1. Vice President
2. Secretary of Defense
3. Secretary of the Navy
4. Secretary of State when representing the President

1-47. The honors rendered when a ship flying the flag of the Secretary of the Navy passes close aboard differ from the honors rendered when a boat flying the flag of the Secretary passes close aboard in that when the boat passes
1. the Admiral's March is played instead of the national anthem
2. the full guard is dispensed with
3. ruffles and flourishes are dispensed with
4. the crew is mustered at quarters instead of manning the rail

1-48. A British cruiser carrying the Queen of England passes a United States Navy carrier anchored in the Thames River. What music is included in the honors rendered by the carrier?
1. Anchors Aweigh
2. The Star Spangled Banner
3. God Save the Queen
4. Admiral's March

1-49. When is the command "attention" sounded during a passing situation of two ships heading in opposite directions in a channel?
1. When the bow of the junior ship is abreast the bridge of the senior ship
2. When the bow of one ship passes the bow of the other
3. When the bow on one ship is 600 yards from the bow of the other
4. When the bridge of the junior ship is abreast of the bridge of the senior ship

1-50. Under what conditions should passing honors be rendered after sunset?
1. To honor a Navy ship with a high official aboard
2. To honor a Coast Guard ship
3. To return the honor of a foreign warship
4. To honor a United States official at a shore station

1-51. Who may direct that passing honors be dispensed with?
1. Commanding officer
2. SOPA
3. Type commander
4. CNO

1-52. What is the meaning of two blasts on the whistle used for passing honors?
1. Attention to starboard
2. Attention to port
3. Render salute
4. Carry on

Learning Objective: Describe the various side honors used for official visits.

1-53. A gun salute is rendered on the arrival of every official who rates
1. 11 guns or more
2. 13 guns or more
3. 15 guns or more
4. 17 guns or more

1-54. What should you do during the firing of a gun salute if you are on the quarterdeck aboard the ship rendering the honors?
1. Render hand salute
2. Stand at attention
3. Stand at parade rest
4. Stand at ease

1-55. For which of the following officers are six side boys presented?
1. Lieutenant
2. Lieutenant commander
3. Commander
4. Commodore

1-56. What honors are rendered to an admiral when he departs his flagship for a formal visit?
1. The crew is required to be in full dress uniform, a 17 gun salute is fired, 4 ruffles and flourishes, the band plays the Admiral's March, a full guard is paraded, and 8 side boys are provided
2. 4 ruffles and flourishes, the band plays the Admiral's March, a full guard is paraded, and 8 side boys are provided
3. 8 side boys are provided
4. None

1-57. When do you break (raise) an official's personal flag during an official visit?
1. When the official's boat or vehicle is sighted
2. On the last gun of the gun salute
3. On the first gun of the gun salute
4. When the official's boat or vehicle comes alongside the ship

1-58. When does the piping of the side begin during an official visit?
1. When the official's boat or vehicle is sighted
2. On the last gun of the salute
3. On the first gun of the gun salute
4. When the official's boat or vehicle comes alongside the ship

1-59. When a gun salute is not prescribed, which of the following indicates the correct order for rendering honors for an official visit?
1. Piping of the side, ruffles and flourishes, music
2. Piping of the side, music, ruffles and flourishes
3. Ruffles and flourishes, piping of the side, music
4. Ruffles and flourishes, music, piping of the side

1-60. When an official arrives for an official visit, in what order are the following honors rendered when a band is not available?
1. Piping of the side, attention, "To the Colors"
2. Piping of the side, "To the Colors", attention
3. Attention, piping of the side, "To the Colors"
4. "To the Colors", attention, piping of the side

1-61. When an official departs from an official visit, in what order are the following honors rendered?
1. Piping of the side, ruffles and flourishes, gun salute
2. Gun salute, piping of the side, ruffles and flourishes
3. Ruffles and flourishes, piping of the side, gun salute
4. Ruffles and flourishes, gun salute, piping of the side

1-62. The Secretary of the Navy is rendered a gun salute upon departure from a Navy ship. His flag is hauled down when
1. he arrives on the quarterdeck
2. he is piped over the side
3. his boat is piped away from the side
4. the last gun has been fired

1-63. Side boys may be paraded in honor of a civil official at any of the following times except
1. during meal hours of the crew
2. on Sunday
3. during regular overhaul
4. after sunset and before sunrise

1-64. What ceremony must always accompany piping of the side?
1. Parading of side boys
2. Gun salute
3. Sounding of "To the Colors"
4. Playing of the national anthem

● For items 1-65 and 1-66, assume that Admiral Jones is relieving Admiral Decatur of command of the Sixth Fleet.

1-65. As the Quartermaster in charge of rendering honors for the occasion, you should break Admiral Jones' personal flag immediately after
1. Admiral Jones reads his orders to the officers and crew
2. the gun salute for Admiral Decatur is fired
3. Admiral Decatur reads his orders to the officers and crew
4. Admiral Decatur's flag is hauled down

1-66. You should haul down Admiral Decatur's flag immediately after
1. Admiral Jones reads his orders to the officers and crew
2. the gun salute for Admiral Decatur's is fired
3. the piping of the side for Admiral Jones
4. the piping of the side for Admiral Decatur

1-67. The honors rendered a flag officer on an official inspection and the honors rendered him on an official visit differ in that on an official inspection he specified the
1. time of the gun salute
2. musical selection to be played
3. ruffles and flourishes to be rendered
4. uniform to be worn

1-68. The honors rendered a United States Senator on an official visit to a ship and the honors rendered him on an official visit to a shore station differ in the
1. uniform worn
2. ruffles and flourishes rendered
3. musical selection played
4. time the gun salute is rendered

1-69. In what way do the honors rendered for an official visit of the Secretary of the Treasury differ from those rendered for an official visit of the Secretary of Defense?
1. Number of side boys paraded
2. Music played
3. Uniform worn
4. Guard paraded

1-70. How many side boys should be paraded as the mayor of San Francisco is piped over the side after an official visit?
1. Two
2. Four
3. Six
4. Eight

Assignment 2

Honors and Ceremonies (continued); Compasses and Degaussing

Textbook, NAVEDTRA 10149-F: Pages 33-60

Learning Objective: Determine occasions and procedures for displaying the national ensign and personal flags and pennants.

2-1. The United States flag is also called the
  1. union jack
  2. national ensign
  3. commission pennant
  4. command flag

2-2. What should you do, when you are at a parade in civilian clothes and are not wearing a hat, if a color guard passes carrying the national ensign?
  1. Come to attention
  2. Come to attention and render the hand salute
  3. Come to attention and place your right hand over your heart
  4. Come to attention and place your right hand over your left shoulder

2-3. If the ensign is not visible during colors, what should military personnel do?
  1. Face in the direction of the ensign, stand at attention
  2. Face the music, render the hand salute
  3. Salute in the direction of the ensign
  4. Face the music, stand at attention

2-4. Where should the national ensign be placed when it is displayed with another flag?
  1. To the right of the other flag
  2. To the left of the other flag
  3. To the right of, and lower than the other flag
  4. To the left of, and higher than the other flag

2-5. In what manner is a period of mourning indicated when the national ensign is on a small portable staff?
  1. The ensign is displayed upside down
  2. The flagstaff is displayed at a 45° angle
  3. Two white crepe streamers are attached to the spearhead of the staff
  4. Two black crepe streamers are attached to the spearhead of the staff

2-6. During a period that the national ensign is to be half-masted, how is the flag handled at (M) morning colors and (E) evening colors?
  1. (M) raised to the half-mast position and secured; (E) lowered directly from half-mast position
  2. (M) raised to the half-mast position and secured; (E) raised to the peak and then lowered for removal
  3. (M) raised to the peak and then lowered to the half-mast position; (E) raised to the peak and then lowered for removal
  4. (M) raised to the peak and then lowered to the half-mast position; (E) lowered directly from half-mast position

2-7. On a ship at sea, the national ensign is flown from the
1. gaff
2. jackstaff
3. main truck
4. flagstaff

2-8. In wartime, no action is commenced nor battle fought without displaying the national ensign.

2-9. When is the national ensign normally flown in a ship's boat?
1. When going alongside another U.S. Navy ship in a United States port
2. While underway in a foreign port during daylight
3. When making guard mail trips
4. At all times while the boat is underway

2-10. How do you reply to a foreign merchant vessel that salutes your ship before morning colors by dipping her national ensign?
1. Reply with signal flags
2. Reply by hoisting the national ensign and returning the salute
3. Reply with a hand salute by the quarterdeck watch
4. Reply with a gun salute

2-11. When should a U.S. Navy ship dip the national ensign first to a foreign ship?
1. At no time
2. Only when that ship is of a nation formally recognized by the United States
3. Only when that ship is of a nation formally allied to the United States
4. Only when that ship is a warship of a nation formally allied to the United States

2-12. Your ship is firing a gun salute to honor the arrival of the United States Secretary of Defense. Where should you display the national ensign if the Secretary's personal flag is not displayed?
1. From the main mast only
2. From the fore mast only
3. From the gaff of the flagstaff only
4. From the main mast and the gaff or the flagstaff

2-13. The national ensign raised to the peak of a mast is said to be
1. closed up
2. half-masted
3. full-dressed
4. two blocked

2-14. The national ensign is displayed at half-mast from 0800 to 1200, or until the completion of a 21-minute gun salute, on
1. Washington's Birthday
2. Memorial Day
3. Veteran's Day
4. all national holidays

2-15. How long is the ensign normally half-masted for the funeral of a ship's crewmember who is being buried at sea?
1. Until sunset of the day of the funeral
2. Until the day following the death of the crewmember
3. Until the body is committed to the deep
4. Until sunset of the seventh day after death

2-16. When at anchor, your ship flies the union jack from the
1. jackstaff
2. flagstaff
3. gaff
4. main

2-17. If you see a naval vessel at anchor flying the union jack at the starboard main yardarm, this is most likely to mean that
1. the vessel's unit commander has recently died
2. funeral services for the commanding officer are in session
3. a diplomatic official of the United States is paying an official visit
4. a court of inquiry is in session

2-18. When embarked in a U.S. Navy boat on an official visit, a Charge d'Affaires of the United States may display from the bow of the boat a
1. commission pennant
2. union jack
3. national ensign
4. miniature of his personal flag

2-19. What size union jack is flown if you are flying a #4 size national ensign?
1. A #2 size union jack
2. A #6 size union jack
3. One the same size as the ensign
4. One the same size as the union of the ensign

2-20. When embarked in a boat on an official visit, a destroyer commanding officer may display from the bow of the boat a
1. commission pennant
2. union jack
3. miniature of the U.S. Navy flag
4. miniature of his personal flag

2-21. When, if ever, is the commission pennant flown at half-mast?
1. Memorial Day
2. Upon the death of the President
3. Upon the death of the commanding officer
4. Never

2-22. No flag may be flown over the national ensign on the same mast except the
1. union jack
2. Red Cross flag
3. church pennant
4. United Nations flag

2-23. Where is the personal flag of an officer displayed on a single-masted ship that is full-dressed?
1. The port yardarm
2. The starboard yardarm
3. The gaff
4. The main truck

2-24. When a flag officer making an official call is embarked in a boat, the boat will fly the ensign aft and the
1. jack forward
2. flag officer's personal pennant forward
3. flag officer's personal pennant aft
4. flag officer's miniature pennant aft

2-25. The display of a flag with blue stars on a white ground indicates a/an
1. civilian employee of the Navy
2. officer of flag rank other than of the line
3. officer below flag rank
4. unit commander

2-26. An officer in command of a squadron and below flag rank is entitled to fly a
1. personal flag
2. broad command pennant
3. burgee command pennant
4. miniature of his personal flag

2-27. When is the United Nations flag displayed on a Navy ship at anchor that is observing a day in honor of the United Nations?
1. 0800 to 1800
2. 0800 to sunset
3. Sunrise to 1800
4. Sunrise to sunset

2-28. Where is the United Nations flag displayed when flown with the United States national ensign?
1. Below and either to the right or the left of the national ensign
2. Above and either to the right or the left of the national ensign
3. At the same height and to the left of the national ensign
4. At the same height and to the right of the national ensign

2-29. Where is the United Nations flag flown during a visit aboard ship by the U.N. Secretary General?
1. Fore truck
2. Main truck
3. Port yardarm
4. Starboard yardarm

2-30. When the President of the United States is aboard a Navy vessel, his flag is displayed at the
1. jackstaff
2. main truck
3. starboard yardarm
4. fore truck

2-31. When the Secretary of Defense visits a Navy ship, his personal flag is displayed at the
1. gaff
2. fore truck
3. main truck
4. starboard yardarm

2-32. Cabinet officers visiting your ship are the Secretaries of Commerce, Interior, State, and Treasury. Whose personal flag is flown by your ship?
1. Secretary of Commerce
2. Secretary of Interior
3. Secretary of State
4. Secretary of Treasury

2-33. What is the principal difference between a dressed ship and full-dressed ship?
1. The dressed ship displays a smaller ensign than the full-dressed ship
2. The full-dressed ship displays a greater number of ensigns than a dressed ship
3. The full-dressed ship displays a rainbow of signal flags
4. The dressed ship displays a rainbow of signal flags, but a lesser amount of ensigns than the full-dressed ship

2-34. What is the principal difference between a ship dressed in honor of a foreign nation and a ship dressed for a United States national holiday?
1. The ship dressed for a United States national holiday has a rainbow of signal flags
2. The ship dressed in honor of a foreign nation has a rainbow of signal flags
3. The ship dressed for a United States national holiday does not fly a national ensign at the mainmast
4. The ship dressed in honor of a foreign nation flies the national ensign of that nation from the mainmast

2-35. Which of the national ensigns is/are required to be placed at half-mast during dress ship?
1. All the national ensigns displayed
2. The national ensigns displayed from the mastheads
3. The national ensign displayed from the flagstaff
4. The largest national ensign displayed

Learning Objective: Identify magnetic compass components, and the causes of compass error; describe how to correct compass error.

2-36. According to the laws of magnetic attraction and repulsion, the south pole of a magnetic will be
1. repelled by both the north pole or south pole of a second magnet
2. attracted by the north pole of a second magnet
3. attracted by both the north pole or south pole of a second magnet
4. attracted by the south pole of a second magnet

2-37. The angular difference between magnetic north and geographic north is known as the angle of
1. opposition
2. apposition
3. variation
4. field density

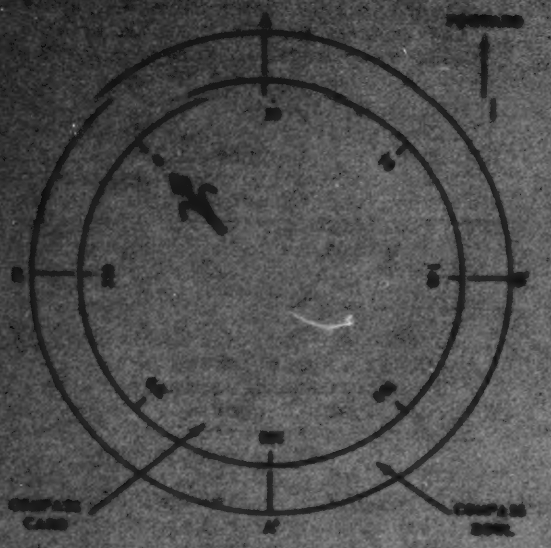


Figure 2A.--Simplified diagram of Navy standard compass

2-38. In figure 2A the lubber's line is represented by line
1. A
2. A'
3. B
4. B'

2-39. What is the ship's heading for the compass shown in figure 2A?
1. 050°
2. 140°
3. 230°
4. 320°

2-40. What part of a magnetic compass installation keeps the compass level, regardless of ship movement?
1. The gimbals
2. The binnacle
3. A pelorus
4. Varsol

2-41. The stand supporting the magnetic compass is known as a
1. pelorus
2. gimbal
3. binnacle
4. repeater

2-42. The amount of compass error caused by deviation varies with the ship's
1. speed
2. heading
3. latitude
4. longitude

2-43. The notation psc after courses and bearings indicates that they were obtained from the
1. steering compass
2. standard compass
3. selsyn compass
4. synchronized gyrocompass

2-44. The purpose of reducing sources of magnetism in the vicinity of a magnetic compass is to reduce
1. degradation
2. deviation
3. delineation
4. depreciation

2-45. Assuming that your ship has emergency steering compass, where would you find this compass?
1. On a fore mast
2. At the forward steering station
3. At the after steering station
4. In the pilothouse

2-46. The ship's magnetic compass record book is submitted for the commanding officer's approval every
1. hour
2. 4 hours
3. month
4. quarter

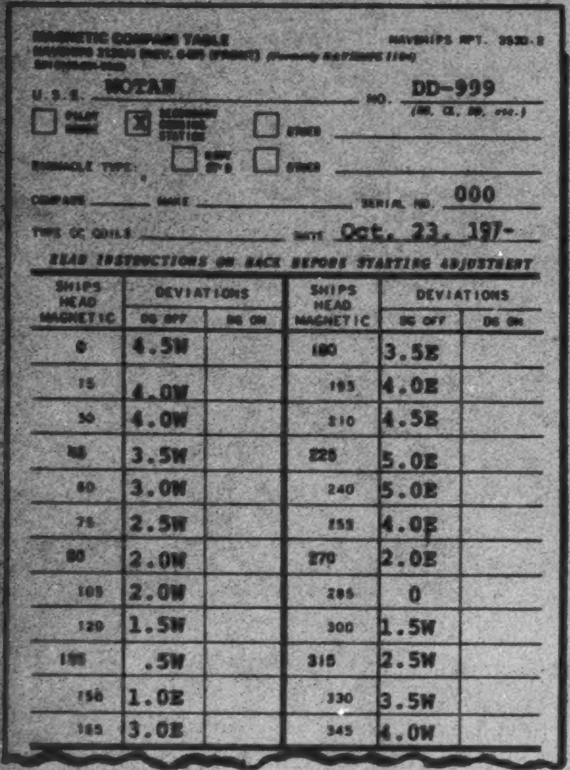
2-47. What are the components of compass error?
1. Variation and precession
2. Precession and cessation
3. Deviation and cessation
4. Variation and deviation

2-48. What fact causes the magnetic compass error called variation?
1. The Earth is not a perfect sphere
2. Metals in ships have magnetic qualities
3. Compasses cannot be constructed without mechanical defects •
4. Positions of Earth's magnetic and geographic poles do not coincide

2-49. What part of a chart shows the magnetic variation for that area?
1. Legend
2. Chart date
3. Compass rose
4. Publication note

2-50. What was the variation in a certain area in 1967 if the variation was 2°W in 1962, and the annual increase is 3'?
1. 1°45'W
2. 1°48'W
3. 2°12'W
4. 2°15'W

2-51. Most deviation tables show the amount of deviation for each
1. 2-1/2° of swing
2. 5° of swing
3. 10° of swing
4. 15° of swing



MAGNETIC COMPASS TABLE [illegible] NAVSHIPS [illegible]

U.S.S. WOTAN NO. DD-999 (BB, CL, DD, etc.)

☐ PILOT HOUSE ☒ SECONDARY CONNING STATION ☐ OTHER

BINNACLE TYPE: ☐ NAVY STD ☐ OTHER

COMPASS ______ MAKE ______ SERIAL NO. 000

TYPE OF COILS ______ DATE Oct. 23, 197-

READ INSTRUCTIONS ON BACK BEFORE STARTING ADJUSTMENT

SHIPS HEAD MAGNETIC	DEVIATIONS		SHIPS HEAD MAGNETIC	DEVIATIONS	
	DG OFF	DG ON		DG OFF	DG ON
0	4.5W		180	3.5E	
15	4.0W		195	4.0E	
30	4.0W		210	4.5E	
45	3.5W		225	5.0E	
60	3.0W		240	5.0E	
75	2.5W		255	4.0E	
90	2.0W		270	2.0E	
105	2.0W		285	0	
120	1.5W		300	1.5W	
135	.5W		315	2.5W	
150	1.0E		330	3.5W	
165	3.0E		345	4.0W	

Figure 2B.--Magnetic compass table

2-52. What is the compass deviation of the USS Wotan (DD 999) in figure 2B for a magnetic course of 195°?
1. 4°E
2. 4°W
3. 5°E
4. 5°W

2-53. How do you convert compass course to true course?
1. Add deviations and variations, regardless of their direction, to the compass course
2. Add easterly deviation and variation to the compass course and subtract westerly deviation and variation from the compass course
3. Subtract deviations and variations, regardless of their direction, to the compass course
4. Subtract easterly deviation and variation from the compass course and add westerly deviation and variation to the compass course

2-54. What is the approximate compass course if the true course is 190° and the variation is 5°W?
1. 179°
2. 189°
3. 191°
4. 201°

2-55. What is the approximate compass course if the magnetic course is 025°?
1. 021°
2. 025°
3. 029°
4. 035°

2-56. What is the approximate true course if the magnetic course is 255° and the variation is 5°W?
1. 250°
2. 251°
3. 259°
4. 260°

2-57. What is the true course made good if the compass course is 170°, variation is 15°E, and deviation is 5°W?
1. 150°
2. 160°
3. 180°
4. 190°

2-58. What compass course must be steered to make good a course of 090°T if the variation is 5°W and the deviation is 10°E?
1. 075°
2. 085°
3. 095°
4. 105°

2-59. What is the magnetic course of a ship if the compass course is 270°, the variation is 10°E, and the deviation is 5°E?
1. 255°
2. 265°
3. 275°
4. 290°

2-60. A ship is steering a compass course of 180° and making good a true course of 176°. If the deviation is 2°E, what is the variation?
1. 2°E
2. 6°E
3. 2°W
4. 6°W

Learning Objectives: Describe reasons for degaussing and its effect on magnetic compasses; Interpret degaussing charts and determine appropriate degaussing coil settings.

2-61. What is the difference between adjusting the compass and compensating the compass?
1. Adjusting is correcting for deviation caused by magnetic material aboard ship; compensating is correcting for deviations caused by degaussing currents
2. Adjusting is correcting for deviations caused by degaussing currents; compensating is correcting for deviations caused by magnetic materials aboard ship
3. Adjusting is computing true course; compensating is computing compass course
4. Adjusting is computing compass course; compensating is computing true course

2-62. The purpose of degaussing is to
1. counteract a ship's magnetic field
2. detect magnetic compass error
3. correct magnetic compass error
4. fix the location of our ship

2-63. What is the purpose of deperming?
1. To prevent disturbances of the magnetic compass
2. To increase the ship's overall magnetic field
3. To stabilize the magnetic compass
4. To reduce the ship's overall magnetic field

2-64. Which degaussing coil counteracts the magnetic field produced by the vertical permanent and the vertical induced magnetization of the ship?
1. F
2. M
3. L
4. A

2-65. Assume that a ship equipped with degaussing gear is in a particular Z- and H-zone. Under which of the following conditions would all degaussing coil currents remain the same?
1. Ship passes to another Z-zone
2. Ship passes to another H-zone
3. Ship changes course, but remains in the same sector
4. Ship moves to another sector that differs in both H and Z

2-66. Your magnetic heading is 220°. The polarity switch for the degaussing coil FI-QI must be set so that the current is
1. negative, at the value specified in Degaussing Chart No. 2
2. positive, at the value specified in Degaussing Course Correction Setting Diagram No. 2
3. negative, at the value specified in Degaussing Course Correction Setting Diagram No. 2
4. positive, at the value specified in Degaussing Chart No. 2

2-67. Which of the following conditions could affect the resistance of a degaussing coil?
1. The polarity of the coils has been changed from negative to positive
2. The voltage from the power supply has increased
3. The ship has crossed into a different Z-zone
4. The polarity of the coils has been changed due to the ship crossing into another H-zone

2-68. What person on the bridge checks the polarity of the coils in the degaussing installation every hour?
1. Steersman
2. Boatswain of the watch
3. Quartermaster of the watch
4. Junior officer of the deck

2-69. What pattern of courses does a ship normally follow in making a run on a degaussing station?
1. Once across the range in a straight line
2. Across the range in a straight line, then back on opposite heading
3. Weaving or zig-zagging course in one direction across the range
4. Weaving or zig-zagging course across the range, first in one direction, then back on opposite heading

2-70. Your ship is ordered to run a magnetic range. Results of this run will be recorded in the ship's degaussing folder by personnel of the
1. bridge
2. degaussing station
3. interior communications gang
4. combat information center

2-71. A change in the current in a degaussing coil automatically affects the compensating coils, ensuring that the compass compensation is undisturbed.

2-72. Your ship's course is 070°. You are adjusting the compass (correcting for deviation) and note in the deviation table that at 060° the deviation (DG off) is 2.5°E and that at 075° it is 1.0°E. What is the approximate deviation for your present course?
1. 0.0°E
2. 1.0°E
3. 1.5°E
4. 2.0°E

Learning Objective: Know the limitations of the gyrocompass.

2-73. What is the main reason for using the magnetic compass rather than the gyrocompass as the standard compass aboard ship?
1. A gyrocompass does not point to true north
2. A gyrocompass is affected by deviation errors
3. A magnetic compass has more residual magnetism
4. A magnetic compass is unaffected by failure of the ship's power supply

2-74. The master gyrocompass is usually started about 4 hours before use because the gyrocompass takes that long to
1. settle
2. become lubricated
3. energize the repeaters
4. reach the proper speed

2-75. Which of the following duties is the responsibility of the Quartermaster on watch?
1. Operating the master gyrocompass
2. Noting the time that the gyrocompass was started
3. Synchronizing the repeaters with the master gyrocompass
4. Lubricating and adjusting the gyro repeaters

Assignment 3

Navigational Aids; Rules of the Road

Textbook, NAVEDTRA 10149-F: Pages 61-77

Learning Objective: Describe various navigational aids, lights, day beacons, and fog signals.

3-1. The system of navigation known as piloting usually determines a ship's position on the basis of
1. known bearings and distances from the point of destination
2. known bearings and distances from the point of departure
3. bearings of visible fixed objects
4. visual estimation of the ship's position

3-2. If your chart does not show the characteristics of a harbor light at Pusan, Korea, you should be able to find the height of this light in the
1. Nautical Almanac
2. Light Lists
3. Navigator's Notebook
4. List of Lights

3-3. Which of the following agencies publishes light lists for lights located in the United States and possessions?
1. Maritime Commission
2. DMAHC
3. Naval Observatory
4. Coast Guard

3-4. What are the standard colors of lights used on navigational aids?
1. Blue, green, and yellow
2. Red, green, and white
3. Red, white, and blue
4. Orange, green, and blue

3-5. Which of the following lights is an occulting light?
1. A light that flashes at regular intervals, with the interval of light always shorter than the interval of darkness
2. A fixed light, varied at regular intervals by one or more flashes of greater brilliance
3. A light totally eclipsed at intervals, with the period of light always greater than the period of darkness
4. A steady light that changes color at regular intervals

In items 3-6 through 3-9 select from column B the type of light described by each set of characteristics in column A.

A. Characteristics

3-6. Showing a single flash at regular intervals with the duration of light always shorter than the duration of darkness

3-7. Change of color at regular intervals

3-8. Groups of two or more flashes at regular intervals

3-9. A fixed light, varied at regular intervals by a flash of greater brilliance

B. Types

1. Alternating
2. Fixed flashing
3. Group flashing
4. Flashing

3-10. How much further can you see an object 140 feet high than an object 70 feet high if you observe both objects from sea level?
1. 3.9 miles
2. 5.7 miles
3. 9.6 miles
4. 13.5 miles

3-11. What is the computed visibility of a light, having an intensity of 10,000 candelas, that is 30 feet above sea level for an observer 10 feet above sea level?
1. 2.0 miles
2. 5.7 miles
3. 9.9 miles
4. 16.2 miles

3-12. The height of a given light is indicated on your chart as 100 feet. The luminous range of this light is 38 nautical miles. Your height of eye is 60 feet. What is the computed visibility of this light?
1. 4.4 miles
2. 8.9 miles
3. 11.5 miles
4. 20.3 miles

3-13. What is the luminous range of a light, having an intensity of 10,000 candelas, on a clear night when the visibility of unlighted objects is 5 nautical miles?
1. 1.7 miles
2. 5.0 miles
3. 8.8 miles
4. 14.0 miles

3-14. You have been asked by the navigator to determine the visibility of a 10,000 candelas light having a height of 135 feet according to your chart. It is a very clear night with a visibility on unlighted objects of approximately 20 nautical miles, and your height of eye is 40 feet. At what distance will the light become visible to your ship?
1. 13.3 miles
2. 14.0 miles
3. 20.5 miles
4. 22.3 miles

3-15. What is the primary purpose of the patterns painted on lighthouses and major light structures?
1. To aid in the identification of the structures
2. To prevent low-flying aircraft from hitting the structure
3. To decorate the structure
4. To make the structure visible at greater distances

3-16. What color are the hulls of United States lightships?
1. Red
2. Black
3. Green
4. Yellow

3-17. What is indicated by the signal LO hoisted by a light vessel?
1. Out of command
2. Anchored on station
3. Not in correct position
4. Relief lightship

3-18. Which of the following lights are shown at night by a lightship anchored on station?
1. Side lights only
2. Stern and masthead lights
3. Forestay and beacon lights
4. Side, forward anchor, and flare-up stern lights

3-19. What is indicated by the red sectors placed in the lanterns of some lighthouses?
1. Safety sectors
2. Danger sectors
3. Restricted areas
4. Recommended approaches

3-20. A narrow green sector in a navigational light may indicate
1. a range
2. a radio beacon
3. water that should be avoided
4. the best water across a shoal

3-21. Some atmospheric conditions may cause a white light to appear
1. red
2. blue
3. green
4. violet

3-22. The specific purpose of buoys is indicated by their
1. shape
2. size
3. color
4. type

3-23. The difference between a gong buoy and bell buoy is that the gong buoy
1. has no built-up framework, while the bell buoy does
2. has to be operated by electricity, while the bell buoy does not
3. sounds a series of different tones, while the bell buoy sounds only one
4. is operated by the motion of the sea, while the bell buoy is operated electrically

3-24. How are whistle buoys and nun buoys shaped?
1. Both are conical
2. Both are cylindrical
3. The whistle buoy is conical, the nun buoy is cylindrical
4. The whistle buoy is cylindrical, the nun buoy is conical

3-25. What does a black buoy indicate when a channel is approached from seaward?
1. The middle of the channel
2. The left side of the channel
3. The right side of the channel
4. An obstruction in the channel

3-26. What is the shape of most red channel buoys?
1. Spar
2. Conical
3. Cylindrical
4. Bell-shaped

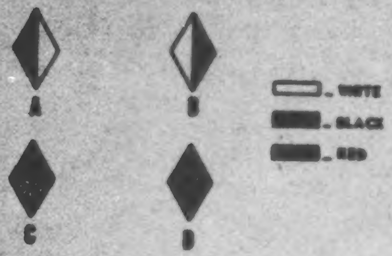


Figure 3A.--Buoy symbols

3-27. In figure 3A channel obstructions are indicated by
1. A only
2. C only
3. A and B
4. C and D

3-28. Which buoy symbol in figure 3A indicates that you should keep the buoy on your port side when you are proceeding seaward?
1. A
2. B
3. C
4. D

In items 3-29 through 3-32 select the meaning from column B that is indicated by the colors of buoys listed in column A.

	A. Colors	B. Meanings
3-29.	Black and white vertically striped	1. Quarantine anchorage
3-30.	White	2. Midchannel
3-31.	Yellow	3. Ordinary anchorage
3-32.	White with green top	4. Dredging area

3-33. What number is carried by the second buoy on the starboard side of a channel viewed from seaward?
1. One
2. Two
3. Three
4. Four

3-34. Which of the following buoys are usually not numbered?
1. Solid-colored buoys
2. Banded buoys
3. Whistle buoys
4. Lighted buoys

In items 3-35 through 3-38 select the meaning from column B that is indicated by the lights of buoys listed in column A.

	A. Lights	B. Meanings
3-35.	Fixed red light	1. Obstruction
3-36.	Fixed green light	2. Port (from seaward)
3-37.	Short-long flashing white light	3. Starboard (from seaward)
3-38.	Interrupted quick-flashing green or red light	4. Midchannel

3-39. A navigator knows that he is on the range when the lights or beacons of the range are observed
1. in line
2. at an angle of 45°
3. at an angle of 90°
4. at an angle of 180°

3-40. A lighthouse transmitting fog signals can be identified from the
1. pitch of the signals
2. intensity of the blasts
3. number of and intervals between blasts in the signal
4. code letter formed by the signal

● While the Intracoastal Waterway (ICW) is primarily a protected waterway for small craft, it often coincides with deep-draft ship channels that lead to the open sea. Where this occurs, the section is known as a joint waterway, the ICW aids to navigation are omitted, and the lateral system of buoyage prevails. The lateral system buoys often are numbered in a direction opposite to those of the ICW. To aid the small boat pilot, however, the joint waterway channel buoys contain ICW identifying marks as follows: a yellow triangle on black buoys, and a yellow square on red buoys.

3-41. You are proceeding up a joint waterway, but shortly you must turn off and follow the ICW. You will have no trouble knowing which channel to take if you remember that all ICW aids to navigation are identified by a
1. yellow band or border
2. black triangle
3. red square
4. green diamond

3-42. ICW buoy numbers will increase as you proceed in the direction of
1. north and east
2. north and west
3. south and east
4. south and west

3-43. Which of the following publications should be consulted for information on aids to navigation in foreign waters?
1. Pub No. 9
2. Coast Pilot
3. Nautical Almanac
4. Sailing Directions

3-44. In which part of the United States are you located if, when proceeding northward in an offshore channel, you have the red channel buoys on your port side?
1. East coast
2. West coast
3. Great Lakes
4. Gulf coast

Learning Objective: Identify sources for various regulations pertaining to safe navigation.

3-45. In which publication will you find both International and Inland Rules of the Road?
1. Pilot Rules
2. Coast Pilot
3. Sailing Directions
4. CG 169

3-46. The United States Inland Rules of the Road apply to all of the following United States waters except
1. New York Harbor
2. the Columbia River
3. the Red River of the North
4. San Francisco Bay

3-47. The first volume of Pilot Rules applies to the same waters as
1. International Rules of the Road
2. United States Inland Rules of the Road
3. Sailing Directions
4. Volume II of Pilot Rules

3-48. Which of the following publications indicates the boundaries between international and inland waters for Alaska?
1. Pilot Rules
2. Coast Pilot
3. International Rules of the Road
4. Sailing Directions

3-49. Your ship is entering a harbor for which no boundary has been established to indicate when you enter inland waters. Inland Rules of the Road will apply when you
1. receive a visual signal from the port authority
2. cross a line approximately parallel to the shoreline that passes through the innermost channel buoy
3. take a pilot aboard your ship
4. cross a line approximately parallel to the shoreline that passes through the outermost buoy

3-50. Which publication do you use as reference if you find that the Inland Rules for a particular situation differ from the rule in Volume I of the Pilot Rules?
1. Volume I of Pilot Rules
2. Coast Pilot
3. Volume II of Pilot Rules
4. Inland Rules

3-51. What is the best source of information on rules of the road that regulate traffic on the Great Lakes?
1. International Rules of the Road
2. United States Inland Rules of the Road
3. Volume I of Pilot Rules
4. Volume II of Pilot Rules

3-52. Local rules for foreign waters not included in Sailing Directions must be obtained from the
1. U.S. Coast Guard
2. DMAHC
3. local authorities
4. U.S. consul in the area

3-53. In the International Rules and the Inland Rules, a vessel "underway" is defined as any ship that is
1. steaming under her own power
2. under construction
3. not at anchor, made fast to the shore or aground
4. making headway

Learning Objective: Identify light characteristics requirements of various vessels. (This objective is continued in assignment 4.)

3-54. During which of the following periods of time must your ship comply with the rules for lights as set forth in International and Inland Rules of the Road?
1. One hour before sunset to one hour after sunrise
2. From sunset to sunrise
3. During hours of darkness
4. While in inland waters

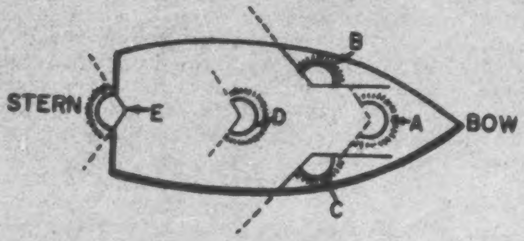


Figure 3B.--Running lights, International Rule

- Items 3-55 through 3-59 refer to figure 3B.

3-55. What running light is indicated by point A?
1. Stern light
2. Range light
3. Masthead light
4. Aircraft warning light

3-56. Under International Rules, what are the visibility requirements for the light at point "A"?
1. Visible from a point dead ahead to a point that is 2 points abaft the beam
2. Visible for at least 5 miles
3. A bright, white light that covers 20 points of the compass
4. All of the above

3-57. What point in figure 3B indicates the range light?
1. A
2. B
3. D
4. E

3-58. How many points of the compass must the light at point D cover?
1. 10 points
2. 12 points
3. 20 points
4. 32 points

3-59. The light at point D is mandatory except for vessels whose length is less than
1. 300 feet
2. 250 feet
3. 200 feet
4. 150 feet

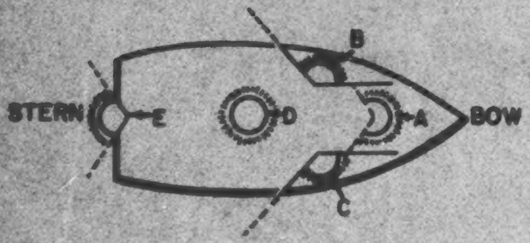


Figure 3C.--Running lights, Inland Rules

- Items 3-60 through 3-63 refer to figure 3C.

3-60. How many points of the compass must the light at point D cover?
1. 10 points
2. 12 points
3. 20 points
4. 32 points

3-61. If the light at point D is a 32-point light, the ship need not show the light at point
1. A
2. B
3. C
4. E

3-62. Under Inland Rules, the light at point B is a
1. 32-point white light
2. 20-point white light
3. 10-point green light
4. 10-point red light

3-63. Under Inland Rules, the light at point E is a
1. 10-point red light
2. 10-point green light
3. 12-point white light
4. 20-point white light

3-64. From how many points abaft the beam should side lights be visible?
1. 1
2. 2
3. 3
4. 4

3-65. The Motorboat Act of 1940 divides powerboats into how many classes?
1. 6
2. 5
3. 4
4. 3

3-66. A powerboat whose length is 54 feet falls into what class under the Motorboat Act of 1940?
1. Class A
2. Class 1
3. Class 2
4. Class 3

- In items 3-67 through 3-69 use the following alternatives.
A. 20-point white light forward
B. 10-point separate side lights
C. 10-point green and 10-point red combined lantern
D. 32-point white light aft

3-67. The light/s required on a power-driven boat under International Rules is/are
1. A only
2. A and either B or C
3. Either B or C and D
4. C and D

3-68. The lights required by the Motorboat Act for a class 2 power-driven boat are
1. A and either B or C
2. A, C and D
3. A, B and D
4. B or C and D

3-69. The light/s required by the Motorboat Act for a power-driven boat under sail is/are
1. A only
2. A and either B or C
3. B or C only
4. B and C or D

3-70. What must be the visibility in miles of (A) white lights and (B) colored lights on motorboats?
1. (A) 3; (B) 1/2
2. (A) 2; (B) 1
3. (A) 1; (B) 2
4. (A) 1/2; (B) 3

3-71. Which of the following lights must a sailing pilot vessel show at the approach of another vessel?
1. Side lights
2. White masthead light
3. Range light
4. Red masthead light

3-72. What additional light must be carried by a power-driven vessel that is not required on a sailing pilot vessel?
1. A flareup light
2. Side light
3. A 32-point white masthead light
4. A 32-point red light below the masthead

3-73. What must be the visibility of the red light on a pilot vessel in inland waters?
1. 1 mile
2. 2 miles
3. 3 miles
4. 4 miles

Assignment 4

Rules of the Road (continued)

Textbook, NAVEDTRA 10149-F: Pages 77-94

Learning Objective (continued): Identify light characteristics requirements of various vessels.

4-1. What light must be displayed by a ship less than 150 feet in length when at anchor?
1. A 20-point white stern light
2. A 32-point white light forward
3. A 32-point white light aft
4. A 10-point white stern light

4-2. When at anchor, what lights must be displayed by a ship 150 feet or more in length?
1. A 32-point red light at the masthead and a 20-point white stern light
2. A 32-point white light forward and a 32-point white light aft
3. A 32-point white light at the masthead and a 20-point white light aft
4. A 32-point white light forward and 20-point side lights

4-3. How many feet above the hull is the forward anchor light on a vessel longer than 150 feet?
1. 30 feet
2. 25 feet
3. 20 feet
4. 15 feet

4-4. What is the day signal for a vessel over 65 feet in length at anchor in inland waters?
1. One black diamond shape forward
2. One red ball aft
3. One black ball forward
4. One black ball aft

4-5. Under International Rules, a power-driven vessel showing two white masthead lights in a vertical line, not less than 6 feet apart, is
1. towing or pushing a vessel, with a length of tow less than 600 feet
2. towing more than one vessel, with a length of tow more than 600 feet
3. out of command, making headway
4. out of command, making no headway

4-6. What do three white lights in a vertical line signify when displayed on a power-driven vessel in international waters?
1. Tow astern, more than 600 feet in length
2. Tow astern, less than 600 feet in length
3. Any tow astern
4. Vessel being pushed

4-7. Under Inland Rules, a power-driven vessel showing two white range lights in a vertical line, not less than 3 feet apart is
1. towing a vessel or vessels, with a length of tow less than 600 feet
2. towing a vessel or vessels, with a length of tow more than 600 feet
3. being pushed by another vessel
4. towing a vessel or vessels alongside

4-8. A power-driven vessel, under Inland Rules, having her towing lights forward and pushing one or more vessels shows, at or near her stern, two amber lights in a vertical line, not less than how many feet apart?
1. 6
2. 5
3. 4
4. 3

4-9. What do three white towing lights signify on a vessel in inland waters?
1. Any tow astern
2. Towing two or more vessels alongside
3. Towing alongside
4. Being pushed

4-10. What is the meaning of the term, "not under command"?
1. No commanding officer aboard
2. Underway with no way on
3. Physically disabled and unable to maneuver in accordance with established rules
4. Underway with way on

4-11. Under International Rules, a power-driven vessel not under command at night will display
1. three red lights in a vertical line, not less than 6 feet apart
2. two white lights in a vertical line, not less than 6 feet apart
3. two red lights in a vertical line, not less than 6 feet apart
4. three white lights in a vertical line, not less than 6 feet apart

4-12. Under International Rules, a power-driven vessel not under command at night shows her side lights if she is
1. making headway
2. making no headway
3. in a congested channel
4. in a fog

4-13. Assume that a U.S. Navy ship is in inland waters and not under command. What signal, if any, is displayed during daylight hours?
1. None
2. The numeral 5 signal flag
3. Two black balls in a vertical line at least 6 feet apart
4. Two red lights in a vertical line at least 6 feet apart

4-14. Under International Rules, a fishing vessel not engaged in fishing will show at night
1. two red lights in a vertical line at least 6 feet apart
2. a red light over a white light in a vertical line separated by no more than 12 feet
3. no lights, but must have a combined lantern ready for display
4. the same lights as other vessels of the same length

4-15. Under International Rules, a fishing vessel engaged in trawling displays a
1. white light over a green light
2. red light over a white light
3. green light over a red light
4. green light over a white light

4-16. Under International Rules, a fishing vessel engaged in fishing with nets or lines of 500 feet or less displays a
1. white light over a green light
2. red light over a white light
3. green light over a red light
4. green light over a white light

4-17. What is the day signal, under International Rules, for a fishing vessel engaged in fishing?
1. Two black balls in a vertical line, at least 6 feet apart
2. One black ball where it can best be seen
3. One black cone where it can best be seen
4. Two black cones in a vertical line with their points together

4-18. Under Inland Rules, a fishing vessel engaged in fishing with lines displays at night a
1. white light over a green light
2. red light over a white light
3. green light over a red light
4. green light over a white light

4-19. What is the day signal, under Inland Rules, for a fishing vessel engaged in fishing?
1. Two black balls in a vertical line, at least 6 feet apart
2. Two black cones in a vertical line, with their points together
3. One black cone hoisted where it can best be seen
4. A basket hoisted where it can best be seen

4-20. Which of the following vessels is considered to be conducting "restricted operations"?
1. A destroyer refueling from a carrier
2. A carrier launching aircraft
3. A minesweeper with sweep gear streamed
4. All of the above

4-21. What special lights must be displayed by a ship engaged in "restricted operations" in international waters?
1. Three white lights in a vertical line
2. Three lights in a vertical line (middle light red and upper and lower lights white)
3. Three red lights in a vertical line
4. Three lights in a vertical line (middle light white and upper and lower lights red)

4-22. What special lights must be displayed by a vessel in inland waters when towing a submerged object?
1. Three lights in a vertical line (middle light red and upper and lower lights white)
2. Three lights in a vertical line (middle light white and upper and lower lights red)
3. Four lights in a vertical line (middle lights red and upper and lower lights white)
4. Four lights in a vertical line (middle lights white and upper and lower lights red)

4-23. What is the day signal, in inland waters, for a vessel moored over a wreck?
1. Two red balls in a vertical line
2. Two shapes in the form of a double frustum of a cone in a vertical line. The upper shape has black and white horizontal stripes and the lower shape is red
3. Two red shapes in the form of a double frustum of a cone in a vertical line
4. Two black cones in a vertical line with their points together

4-24. What is the meaning of two red balls in a vertical line, under Inland Rules, when displayed on a vessel during daylight hours?
1. The vessel is moored over a wreck
2. The vessel is fishing with lines
3. The vessel is towing a submerged object
4. The vessel is a dredge moored in a stationary position

4-25. Under International Rules, what lights must be shown by a vessel under 150 feet that has gone aground?
1. Three red lights in a vertical line
2. Three white lights in a vertical line
3. Two red lights in a vertical line plus a white light near the bow and a white light near the stern
4. Two red lights in a vertical line plus a white light near the bow

4-26. What is the court-approved day signal for a vessel aground in inland waters?
1. Three black balls in a vertical line
2. Two black balls in a vertical line
3. One black ball
4. One red ball

4-27. Under Inland Rules, what lights are shown by the last barge in a tandem tow?
1. Side lights and a 20-point stern light
2. Side lights and two 32-point white lights
3. A 20-point stern light only
4. Two 32-point white lights only

4-28. Under Inland Rules, the lead barge of a tow being pushed ahead carries what lights?
1. A white light forward and aft
2. A white light forward
3. Side lights forward and a stern light
4. Side lights forward

4-29. An aircraft carrier cannot show navigational lights in accordance with the rules covering ships of her length and tonnage. Deviation from the standard procedure is

1. ignored by the International Rules
2. prohibited by the International Rules
3. provided for by United States laws and statutes
4. prohibited by both International and Inland Rules

4-30. When seen from ahead, a minesweeper shows two green lights, one from the masthead and one to your right, in addition to her normal running lights. These lights indicate that

1. she is preparing to stream sweep gear
2. a danger exists if the minesweeper is passed close aboard on either side
3. a danger exists if the minesweeper is passed close aboard on the port side
4. sweep gear is not streamed, and you can pass close aboard on either side

4-31. A vessel showing a rapidly flashing amber light in addition to normal running lights is a

1. fishing vessel
2. carrier conducting flight operations
3. minesweeper engaged in sweep operations
4. submarine on the surface

Learning Objective: Determine Inland and International Fog Signals.

4-32. A power-driven vessel in fog, in international waters, has been sounding one prolonged blast at 2-minute intervals. The vessel is

1. backing down
2. not under command
3. stopped with no way on
4. underway

4-33. A power-driven vessel underway in a fog in inland waters should sound her fog signals at intervals no longer than

1. 1 min
2. 2 mins
3. 3 mins
4. 4 mins

4-34. In international waters a power-driven vessel stopped in a fog and having no way on sounds

1. a prolonged blast at 2-minute intervals
2. a short blast at 1-minute intervals
3. a short and a prolonged blast at 1-minute intervals
4. two prolonged blasts at intervals of not more than 2 minutes

4-35. What signal does a sailing vessel underway in fog sound when on the port tack?

1. 4 blasts
2. 3 blasts
3. 2 blasts
4. 1 blast

4-36. What signal indicates a vessel at anchor in inland waters in a fog?

1. Five short blasts at intervals of not more than 1 minute
2. Rapid ringing of the ship's bell for 5 seconds at intervals of not more than 1 minute
3. Two prolonged blasts at intervals of not more than 1 minute
4. Three prolonged blasts at intervals of not more than 2 minutes

4-37. A vessel over 350 feet in length, at anchor in international waters during fog, warns approaching ships of its presence both by prescribed ringing of a forward bell and by sounding another signal aft (gong, etc.) for about

1. 5 seconds at 1-minute intervals
2. 30 seconds at 1-minute intervals
3. 1 minute at 5-second intervals
4. 1 minute at 5-minute intervals

4-38. In a fog, three distinct claps of a bell followed by a rapid ringing of the bell followed by three more distinct claps indicates a ship in international waters that is

1. underway with no way on
2. at anchor
3. aground
4. being towed

4-39. What action should be taken by a vessel that hears a fog signal forward of her beam but from an unknown direction?
1. Stop her engines
2. Answer the signal
3. Change course away from the sound of the signal
4. Maintain her course and speed

Learning Objective: Determine steering and sailing rules to be used in inland and international waters.

4-40. In general what do whistle signals indicate in international and inland waters?
1. International waters, execution; inland, intention
2. International waters, intention; inland, execution
3. In both international waters and inland waters, execution
4. In both international waters and inland waters, intention

● Select the whistle signal listed as alternatives below that matches the meaning listed in items 4-41 through 4-44.
1. One short blast
2. Two short blasts
3. Three short blasts
4. Four or more short blasts

4-41. My engines are going astern.

4-42. Danger signal (inland waters).

4-43. I am altering my course to port.

4-44. I am alterning my course to starboard.

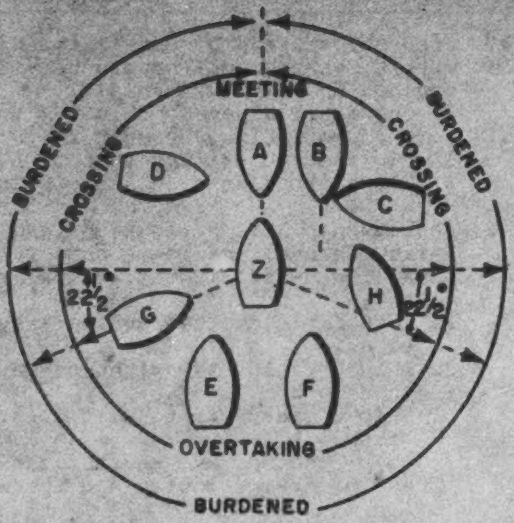


Figure 4A.--Meeting, crossing, and overtaking situations

● For items 4-45 through 4-50, refer to figure 4A. Assume ship Z is a power-driven vessel.

4-45. What signal, if any, must be sounded when ships Z and B meet in inland waters?
1. No signal is required of either ship
2. Three short blasts must be sounded by one of the ships and it must be answered by the other ship with three short blasts
3. Two short blasts must be sounded by one of the ships and it must be answered by the other ship with two short blasts
4. One short blast must be sounded by one of the ships and it must be answered by the other ship with two short blasts

4-46. What action should be taken when ships Z and C meet in international waters?
1. Ship C should alter course to pass astern of ship Z
2. Ship Z should maintain her course and speed
3. Ship C should keep clear of ship Z
4. Ship Z should keep clear of ship C

4-47. When ships Z and D meet in inland waters, what signal should be sounded and by which ship?
1. One short blast by ship D
2. One short blast by ship Z
3. Two short blasts by ship D
4. Two short blasts by ship Z

4-48. Assume ship Z is navigating in a narrow channel and meets ship D, a sailing vessel. What action is taken?
1. Ship Z yields the right-of-way to ship D
2. Ship D yields the right-of-way to ship Z
3. Ship Z maneuvers to pass clear of ship D
4. Ship D sounds one short blast and maintains course and speed

4-49. What signal must be sounded if ships E and Z meet in inland waters, and ship E intends to pass ship Z to port?
1. One short blast
2. Two short blasts
3. Three short blasts
4. Four or more short blasts

4-50. What signal must ship Z sound if she considers it unsafe for ship E to pass to port?
1. One short blast
2. Two short blasts
3. Three short blasts
4. Four or more short blasts

4-51. Sailing and steering rules, rules for sound signals, and rules for lights are designed to
1. let you know as much as possible about the other ship
2. let you know what the other ship is doing
3. help you keep clear of the other ship
4. do all of the above

4-52. If the bearing of an approaching vessel does not change appreciably, the vessel is said to be
1. the burdened vessel
2. the privileged vessel
3. on a danger bearing
4. on a collision course

4-53. The vessel that has the right-of-way is called the
1. burdened vessel
2. privileged vessel
3. vessel keeping clear
4. vessel having the other vessel to starboard

4-54. Under International and Inland Rules, which of the following navigational codes permits a departure from the Rules of the Road when a ship is in extremis?
1. Rule of Good Seamanship
2. General Prudential Rule
3. Pilot Rules
4. Steering and Sailing Rules

4-55. Under International and Inland Rules, which of the following navigational codes applies when a ship is in danger of collision but not yet in extremis?
1. Rule of Good Seamanship
2. General Prudential Rule
3. Pilot Rules
4. Steering and Sailing Rules

- For items 4-56 through 4-62, refer to figure 4A.

4-56. What action should be taken if ships Z and A meet in either inland or international waters?
1. Ship A should maintain course; ship Z should alter course to starboard
2. Both ships should alter course to starboard and pass port-to-port
3. Ship Z should maintain course; ship A should alter course to starboard
4. Both ships should alter course to port and pass starboard-to-starboard

4-57. What whistle signal is sounded when ships Z and A use the correct passing procedure?
1. Ship Z sounds one short blast; ship A remains silent
2. Both ships sound one short blast
3. Ship A sounds one short blast; ship Z remains silent
4. Both ships sound two short blasts

4-58. What passing procedure should ships Z and B follow if they are in international waters?
1. Ship B should alter course to pass ship Z to starboard
2. Ship Z should alter course to pass ship B to starboard
3. Both ships should maintain course and pass starboard-to-starboard
4. Both ships should alter course and pass port-to-port

4-59. When ships Z and A meet in inland waters, ship Z signifies her intention to pass starboard-to-starboard by sounding two short blasts on her whistle. What action does ship A take if she agrees to this procedure?
1. She continues on her course
2. She sounds one short blast
3. She sounds two short blasts
4. She sounds three short blasts

4-60. Assume ship Z is in international waters and meets ship D, a sailing vessel. What action is taken?
1. Ship Z yields the right-of-way to ship D
2. Ship D yields the right-of-way to ship Z
3. Ship D maneuvers to pass clear of ship Z
4. Ship Z sounds one short blast and maintains course and speed

4-61. What action must be taken by ship C when ships Z and C meet in either inland or international waters?
1. Reduce speed and maintain course
2. Maintain course and speed until the danger is past
3. Increase speed and maintain course
4. Reduce speed and alter course away from the other vessel

4-62. What whistle signal is made by ship C to ship Z if ship C intends to maintain course and speed in inland waters?
1. One short blast
2. Two short blasts
3. Three short blasts
4. Four short blasts

4-63. Under International Rules what do three blasts indicate?
1. "I am directing my course to starboard."
2. "I am directing my course to port."
3. "My engines are going astern."
4. "I am out of command."

4-64. What is the whistle signal sounded in inland waters that indicates execution rather than intention?
1. 1 short blast
2. 2 short blasts
3. 3 short blasts
4. 4 or more short blasts

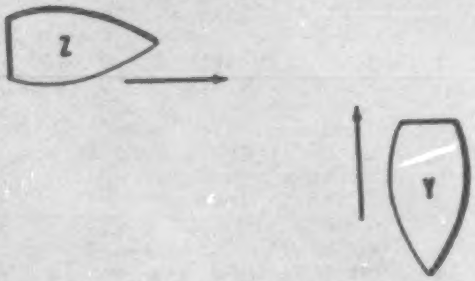


Figure 4B.--Ship backing in open water onto the track of another

4-65. Vessel Y in figure 4B is backing down. In this crossing situation what procedure should the vessels follow?
1. Vessel Y should maintain her course and speed; vessel Z should keep clear
2. Vessel Z should maintain her course and speed; vessel Y should keep clear
3. Vessel Z should maintain her course, engines full astern
4. Vessel Y should maintain her course, engines full ahead

4-66. When may a vessel request the right-of-way under the Rule of Good Seamanship?
1. Only after the privileged vessel sounds her original signal
2. Either before or after the privileged vessel sounds her original signal
3. Only in the daytime
4. Only at night

- For items 4-67 and 4-68, refer to figure 4A.

4-67. Ships in figure 4A that are considered to be overtaking ship Z include
1. ships D and H
2. ships F and G
3. ships A and E only
4. ships B and H only

4-68. In inland waters, if ship F overtakes ship Z and intends to pass to starboard she sounds
1. one short blast and ship Z answers with one short blast
2. two short blasts and ship Z answers with two short blasts
3. one short blast and ship Z answers with two short blasts
4. two short blasts and ship Z answers with one short blast

4-69. In inland waters, a steam vessel approaching a sharp bend in a channel must sound
1. one short blast
2. one long blast
3. four short, rapid blasts
4. four prolonged blasts

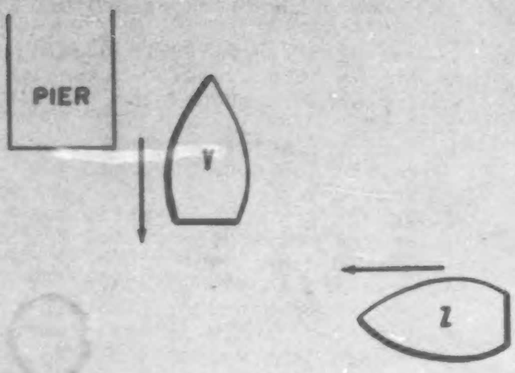


Figure 4C.--Ship backing from a pier onto the track of another

4-70. In figure 4C vessel Y is backing out into a fairway. What is the proper procedure for the vessels to follow?
1. Vessel Z should maintain course and back down
2. Vessel Y should maintain course and go ahead
3. Both vessels should keep clear
4. Vessel Z should alter course to port and maintain speed

Learning Objective: Determine Inland and International Distress Signals.

4-71. What is the daytime distress signal in inland waters for a U.S. Navy ship?
1. National ensign flown upside down
2. Three short blasts repeated at one-minute intervals
3. Continuous sounding with any fog-signal apparatus or firing a gun
4. Red rockets, fired at one-minute intervals

4-72. What signal would a submarine make in an emergency to indicate that she is going to surface?
1. Red Very signal
2. Green Very signal
3. Red smoke bomb
4. Yellow smoke bomb

Assignment 5

Charts and Publications; Time and Timepieces

Textbook, NAVEDTRA 10149-F: Pages 95-122

Learning Objective: Describe charts normally used for navigation; Interpret chart numbers.

5-1. What type of chart projection is most commonly used in the Navy?
1. Polar Stereographic
2. Mercator
3. Gnomonic
4. Stereographic

5-2. In the construction of a Mercator chart, the surface of the Earth is projected on a
1. plane tangent to the Earth's surface at any point
2. sphere tangent to the Equator
3. plane tangent to the poles
4. cylinder tangent to the Equator

5-3. On the Mercator projection, meridians appear as
1. vertical lines that are parallel and equally spaced
2. parallel lines whose spacing increases as longitude increases
3. straight lines that intersect at the poles
4. curved lines that bend toward the point where the projection was made

5-4. On a Mercator projection, parallels appear as
1. vertical lines that are parallel and equally spaced
2. parallel lines whose spacing increases as latitude increases
3. straight lines that intersect at the poles
4. curved lines that bend toward the point where the projection is made

5-5. The expansion of the latitude scale is greatest on the Mercator projection in the vicinity of the
1. Equator
2. poles
3. 180th meridian
4. Greenwich meridian

5-6. The construction of the Mercator chart makes it valuable in navigation because
1. a course line can be plotted as a straight line
2. a course line can be plotted as a curved line
3. the areas represented on the chart have no distortion
4. great circle tracks can be plotted as a single straight line

5-7. On a Mercator projection, a rhumb line appears as a
1. curved line that is a great circle track
2. straight line that crosses every meridian at the same angle
3. curved line that is the shortest distance between two points on the surface of the Earth
4. a straight line that is parallel to all meridians

5-8. Charts constructed on the Gnomonic projection are often used for
1. plotting original surveys
2. navigating in polar regions
3. celestial navigation
4. maneuvering inshore

5-9. The Gnomonic projection is particularly helpful in plotting
1. great circle tracks
2. rhumb line routes
3. channel courses
4. harbor approaches

5-10. On a Gnomonic projection, a great circle appears as a
1. curved line that crosses every meridian at the same angle
2. straight line that is the shortest distance between two points on the surface of the Earth
3. straight line that crosses every meridian at the same angle
4. curved line that is the shortest distance between two points on the surface of the Earth

5-11. On a Mercator projection, a great circle track appears as a
1. straight line that crosses every meridian at the same angle
2. series of straight lines that appear as a curved line
3. single rhumb line
4. single straight line

5-12. A chart that covers a relatively large area is generally called a
1. large scale chart
2. Mercator chart
3. Gnomonic chart
4. small scale chart

5-13. Coast and approach charts generally have a chart scale of
1. 1:100,000 to 1:600,000
2. 1:2,400 to 1:50,000
3. 1:50,000 to 1:100,000
4. 1:600,000 or smaller

5-14. Most charts that are used by the Navy are issued by which of the following agencies?
1. British Admiralty
2. Defense Mapping Agency (DMA)
3. National Ocean Survey
4. All the above

5-15. Charts showing approaches to large areas of the coast, and having a scale of 1:600,000 and smaller, are known as
1. navigational charts
2. coastal charts
3. generally sailing charts
4. harbor charts

5-16. In what measurement units will water depths be shown on new charts?
1. Feet
2. Fathoms
3. Meters
4. Both 2 and 3 above

5-17. The approximate position is marked on the chart by
1. the lower point of the diamond
2. the upper point of the diamond
3. the center of the diamond
4. a dot near the diamond

5-18. What charts indicate the best routes between ports and also give area hydrographic, navigational, and meteorological information in graphic form?
1. Harbor charts
2. Pilot charts
3. Coastal charts
4. General sailing charts

5-19. How often does the DMAHC issue Pilot Charts of the North Atlantic Ocean?
1. Weekly
2. Monthly
3. Quarterly
4. Yearly

5-20. What chart category has charts with one-digit numbers but no chart scale?
1. One
2. Two
3. Three
4. Four

5-21. What chart category covers the nine ocean basins?
1. 5
2. 4
3. 3
4. 2

5-22. General Chart 30 comes under category two and covers the
1. Mediterranean with a scale of 1:9,000,001 and smaller
2. Caribbean with a scale of 1:2,000,001 to 1:9,000,000
3. standard time zones of the world
4. magnetic inclination or dip

5-23. What chart category consists of a non-navigational special-purpose charts with four-digit numbers, such as the maneuvering board?
1. One
2. Two
3. Three
4. Four

5-24. A chart covering a small area in one of the nine world regions has a number consisting of how many digits?
1. 2
2. 3
3. 4
4. 5

5-25. Which of the following general areas is covered by Region Four in Chart Category Four?
1. Indian Ocean
2. East Asia
3. Scandinavia, Baltic, and USSR
4. Western Europe, Iceland, Greenland and the Arctic

5-26. What type of chart is indicated by the alphabetical character "M" followed by four digits?
1. A bottom contour chart with loran-C information
2. A non-submarine contact chart with omega information
3. A non-submarine contact chart with loran-C information
4. A bottom contour chart with omega information

5-27. Which of the following chart numbers would be classified as a combat chart?
1. 51000
2. B2000
3. 93C22
4. C4000

Learning Objective: Identify various navigational publications.

5-28. What DMAHC publication should you consult to determine your ship's minimum chart allowance?
1. Chart 1
2. Publication 1-PCL
3. Publication 1-N
4. Publication 1-V

5-29. A complete list of all nautical charts available to the Navy through the DMAHC is found in
1. Publication 1-N-L
2. Monthly Information Bulletin
3. Sailing Directions
4. Light Lists

5-30. In what publication will you find nautical chart corrections?
1. Pubiication 1-V
2. Notice to Mariners
3. Sailing Directions
4. Light Lists

5-31. Which of the following publications contains information on the anchorage facilities of foreign ports?
1. Coast Pilots
2. Sailing Directions
3. Notice to Mariners
4. Portfolio Chart List

5-32. Which of the following publications contains information pertaining to the availability of repair facilities in the different ports of the United States?
1. Coast Pilots
2. Light Lists
3. Sailing Directions
4. Portfolio Chart List

5-33. In which publication will you find brief descriptions of foreign lighthouses?
1. Coast Pilots
2. List of Lights
3. Notice to Mariners
4. Portfolio Chart List

5-34. Information concerning lights located in the United States and its possessions is published by the
1. Defense Mapping Agency
2. National Ocean Survey
3. Coast Guard
4. Naval Observatory

Learning Objective: Recognize procedures for stowing and correcting charts and for ordering charts and publications.

5-35. In which direction are the geographical subregions (portfolios) of each region numbered?
1. Clockwise around the world
2. Counterclockwise around the world
3. Counterclockwise around the continents
4. Clockwise around the continents

5-36. How should charts be stowed?
1. Flat only
2. Flat or folded
3. Folded or rolled
4. Flat, folded, or rolled

5-37. Which of the following publications is the main source of corrections to charts and light lists?
1. Notice to Mariners
2. Nautical Almanac
3. Supplement to Light Lists
4. Monthly Corrections

5-38. Into how many sections is each Notice to Mariners divided?
1. Two
2. Three
3. Five
4. Seven

5-39. In your chart correction card file, you must have a card for each
1. portfolio
2. chart
3. Notice to Mariners
4. chart not in a portfolio

5-40. What chart corrections, if any, must you make as soon as possible after receiving a new Notice to Mariners?
1. All charts affected by the changes in the Notice to Mariners
2. All charts of the waters in which your ship may be expected to operate during the next year
3. Only the charts in current use in the operating area of your ship
4. None; changes are entered on the chart correction cards only

5-41. Which of the following publications is the main source of corrections to DMAHC publications?
1. Notice to Mariners
2. Monthly Information Bulletin
3. DOD Aeronautical Chart Updating Manual
4. DOD Aeronautical Chart Classified Bulletin Digest

5-42. Who determines which charts are to be kept corrected to date?
1. Chief of Naval Operations
2. Ship's navigator
3. Ship's leading quartermaster
4. Commanding officer

5-43. All chart corrections should be made with
1. black pencil lead
2. red pencil lead
3. ink
4. red ink only

5-44. Where, on the chart, should you record the year and number of the Notice to Mariners from which corrections were made?
1. Upper right-hand corner
2. Upper left-hand corner
3. Lower right-hand corner
4. Lower left-hand corner

5-45. To which office should ships of the Pacific Fleet normally send chart requests?
1. DMA depot, Philadelphia, Penn.
2. DMA depot, Boston, Mass.
3. DMA depot, Seattle, Wash.
4. DMA depot, Clearfield, Utah

5-46. What form is used for ordering new charts?
1. DD 1410-D
2. DD 1150
3. DD 1149
4. DD 1110

5-47. From which activity should you order a Nautical Almanac?
1. DMA depot, Clearfield, Utah
2. DMA depot, Philadelphia, Penn.
3. U.S. Naval Observatory
4. Naval Sea Systems Command

Learning Objective: Describe the relationship between time and arc.

5-48. An error of 1 minute in recording the time of a celestial observation on the Equator causes an error in longitude of
1. 1.5 nautical miles
2. 5 nautical miles
3. 10 nautical miles
4. 15 nautical miles

5-49. What is the time equivalent of 25° of arc?
1. 1^h30^m
2. 1^h40^m
3. 1^h50^m
4. 2^h0^m

	°	'	"
5^h	(A)	0	0
9^m	2	(B)	0
12^s	0	3	(C)

Figure 5A.--Converting time to arc

5-50. What number should you put in blank (A) of figure 5A?
1. 15
2. 75
3. 150
4. 300

5-51. What number should you put in blank (B) of figure 5A?
1. 2
2. 4
3. 9
4. 15

5-52. What number should you put in blank (C) of figure 5A?
1. 0
2. 3
3. 4
4. 15

	h	m	s
112°	(A)		
50'		(B)	
45"			(C)

Figure 5B.--Converting arc to time

5-53. What number should you put in blank (A) of figure 5B?
1. 1
2. 3
3. 7
4. 28

5-54. What number should you put in blank (B) of figure 5B?
1. 1
2. 3
3. 7
4. 28

5-55. What number should you put in blank (C) of figure 5B?
1. 1
2. 3
3. 7
4. 28

5-56. What is the equivalent in arc to $8^h26^m46^s$ in time?
1. 120°36'40"
2. 124°50'40"
3. 126°41'30"
4. 127°10'

5-57. What is the time equivalent of 111°44'45" of arc?
1. $7^h3^m1^s$
2. $7^h24^m14^s$
3. $7^h26^m59^s$
4. $7^h34^m24^s$

5-58. What is the time equivalent of an arc measuring 50°32'30"?
1. $3^h20^m8^s$
2. $3^h22^m10^s$
3. $4^h2^m2^s$
4. $4^h10^m4^s$

Learning Objectives: Define the different kinds of time, identify time zones, and determine GMT (UT).

5-59. The equation of time is the name given to the difference between
1. mean time and zone time
2. apparent time and mean time
3. apparent time and zone time
4. zone time and Greenwich mean time

5-60. Over which meridian in relation to your position is the Sun located when local apparent time is 1800?
1. 90° to the west
2. 180° to the west
3. 90° to the east
4. 180° to the east

5-61. Why is mean time, rather than apparent time, used in navigation?
1. The equation of time is constant when mean time is used
2. Stars and planets are identified by mean time
3. Apparent time cannot be converted into arc measurements
4. The days are of equal length when measured by mean time

In items 5-62 thru 5-64, select the reference point from column B that is used to calculate the time listed in column A.

	A. Times	B. Reference Points
5-62.	Sidereal	1. Longitude
5-63.	Zone	2. Moon
5-64.	Solar Apparent	3. First point of Aries
		4. Sun

5-65. How many degrees does a time zone extend on either side of the standard time meridian?
1. 7-1/2°
2. 15°
3. 24°
4. 30°

5-66. Which of the following local times is equal to the zone time of an entire time zone?
1. Apparent time at the Greenwich meridian
2. Apparent time at the standard time meridian
3. Mean time at the Greenwich meridian
4. Mean time at the standard time meridian

5-67. Which of the following relations holds true in time zones that are west of Greenwich?
1. The ZD is plus and is added to GMT (UT) to get ZT
2. The ZD is plus and is added to ZT to get GMT (UT)
3. The ZD is minus and is added to GMT (UT) to get ZT
4. The ZD is minus and is added to ZT to get GMT (UT)

5-68. What correction must be applied to GMT to compute zone time at 158°W longitude?
1. Plus 10 hours
2. Minus 10 hours
3. Plus 11 hours
4. Minus 11 hours

5-69. What is GMT at 83°W longitude if zone time is $12^h18^m4^s$?
1. $6^h18^m4^s$
2. $7^h18^m4^s$
3. $17^h18^m4^s$
4. $18^h18^m4^s$

5-70. What is the numerical value of GMT if ZT is $10^h40^m10^s$ at 89°36'17"W longitude?
1. $4^h40^m10^s$
2. $5^h40^m10^s$
3. $15^h40^m10^s$
4. $16^h40^m10^s$

5-71. What is the zone time and date at 170°W longitude when it is noon on 16 March zone time at 30°E longitude?
1. 2100, 15 March
2. 2300, 15 March
3. 2100, 16 March
4. 2300, 16 March

5-72. What is the time and date at 170°E longitude when it is noon on 24 December at 125°W longitude?
1. 0600, 24 December
2. 0700, 24 December
3. 0600, 25 December
4. 0700, 25 December

5-73. What is LMT at 69°W longitude when ZT for that zone is $4^h36^m16^s$?
1. $4^h8^m16^s$
2. $4^h12^m16^s$
3. $5^h0^m16^s$
4. $5^h4^m16^s$

5-74. What is ZT at 158°W longitude when LMT is $5^h30^m45^s$?
1. $5^h2^m45^s$
2. $5^h10^m45^s$
3. $5^h40^m45^s$
4. $5^h58^m45^s$

5-75. What kind of time is usually indicated by a ship's clock?
1. LMT
2. ZT
3. GMT
4. LAT

Assignment 6

Time and Timepieces (continued); Introduction to Navigation; Dead Reckoning and Piloting

Textbook, NAVEDTRA 10149-F: Pages 122-151

Learning Objective: Describe timepieces used aboard ship and how to determine their error.

6-1. Who is responsible for having a deck clock repaired?
1. Bridge messenger
2. Time orderly
3. Quartermaster
4. Navigator

6-2. Who is responsible for determining when the ship's clocks are to be wound?
1. Bridge messenger
2. Time orderly
3. Quartermaster
4. Navigator

6-3. What method is used to neutralize the ship's motion in a chronometer installation?
1. Foam rubber mounts
2. Gimbal mounts
3. Gyroscopic mounts
4. Shock absorber mounts

6-4. One of the differences between an unmodified size 85 chronometer and a size 35 chronometer is that the size 85 chronometer has
1. a dial 1-1/2 inches smaller than the size 35 chronometer
2. a second hand that jumps one second every other tick
3. a dial 1-1/2 inches larger than the size 35 chronometer
4. an external winding stem

6-5. The chronometer stowage locker should be located as near as possible to the ship's
1. keel
2. hull
3. wardroom
4. centerline

6-6. (A) How long can most chronometers run without being rewound, and (B) how often should a ship's chronometer be wound?
1. (A) 36 hours, (B) every 18 hours
2. (A) 36 hours, (B) every 24 hours
3. (A) 56 hours, (B) every 18 hours
4. (A) 56 hours, (B) every 24 hours

6-7. To ensure uniform performance, chronometers are customarily
1. returned to the chronometer pool for rewinding
2. allowed to run down and then rewound
3. reset each day at 1130
4. wound at the same time each day

6-8. The indicator dial on the face of a chronometer gives the time elapsed since the most recent
1. resetting
2. inspection
3. winding
4. run-down

6-9. Chronometer error is the difference between chronometer time and
1. ZT
2. GMT (UT)
3. LMT
4. LAT

6-10. What is the average daily rate (ADR) of a chronometer that is fast by 5 minutes 31 seconds on 1 September 1976 and fast by 6 minutes 43 seconds on 30 September 1976?
1. -2.4 s/day
2. +2.4 s/day
3. +11.03 s/day
4. -13.43 s/day

6-11. The hour signal in the radio time signals is preceded by a break lasting for
1. 1 sec
2. 4 sec
3. 5 sec
4. 9 sec

6-12. During a radio time signal beginning at 5 minutes before the hour, the signal follows a specific pattern for each minute. For the first minute, the pattern consists of omitting the signal for seconds
1. 29 and 51 through 59
2. 29, 51, and 56 through 59
3. 29, 52, and 56 through 59
4. 29, 53, and 56 through 59

6-13. When should you try to make C-W comparisons to obtain the most accurately timed observations?
1. Both before and after sights
2. At least once a watch
3. Every day at 1130
4. Every 10 days

6-14. The chronometer time of a celestial observation is obtained by adding C-W to
1. LMT
2. GMT (UT)
3. WT
4. ZT

6-15. GMT (UT) is obtained by applying a CE correction to
1. LAT
2. LMT
3. ZT
4. CT

6-16. What is the value of C-W if the comparing watch reads $3^h20^m10^s$ when the chronometer reads $5^h10^m00^s$?
1. $1^h10^m10^s$
2. $1^h49^m50^s$
3. $2^h10^m10^s$
4. $8^h30^m10^s$

Learning Objective: Identify various methods of determining a ship's position.

● Items 6-17 thru 6-20 describe means of determining a ship's position. For each item, name the method of navigation described, using the following alternatives.
1. Piloting
2. Dead reckoning
3. Celestial navigation
4. Electronic navigation

6-17. Referring the ship's location to that of bodies in the sky, such as the Sun, Moon, planets, or stars

6-18. Using bearings and distances from objects you can see on the Earth's surface, such as lighthouses, steeples, and points of land

6-19. Using bearings and distances obtained with equipment such as radio-direction finders, loran, and radar

6-20. Estimating the direction and distance traveled from a known point of departure

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Learning Objective: Explain how meridians and parallels are used to locate any given point on Earth.

6-21. The true shape of the Earth is that of an oblate spheroid; for purposes of celestial navigation, its shape is considered to be that of a
1. paraboloid
2. prolate spheroid
3. cylinder
4. sphere

6-22. Imaginary lines running around the Earth and through the poles are called
1. parallels
2. meridians
3. isobars
4. isopleths

6-23. The Earth is divided into the Northern and Southern Hemispheres by an imaginary line called the
1. Equator
2. Earth's axis
3. Greenwich meridian
4. international date line

6-24. How many degrees of arc are in a circle?
1. 60
2. 180
3. 360
4. 3600

6-25. A nautical mile is approximately equal to
1. 5280 feet or 1584 meters
2. 5820 feet or 1746 meters
3. 6000 feet or 1800 meters
4. 6076 feet or 1852 meters

6-26. What is the starting point for numbering meridians?
1. The Equator
2. The North Pole
3. Washington, D.C.
4. Greenwich, England

6-27. The zero meridian is called the
1. Greenwich meridian
2. Equator
3. Earth's axis
4. international date line

6-28. The Earth is divided into the Eastern and Western Hemispheres by an imaginary line formed by the
1. Equator
2. Greenwich and 180th meridians
3. 0° parallel
4. 90°E and 90°W meridians

6-29. Parallels are numbered from 0° to
1. 90°N and S
2. 180°N and S
3. 180°E and W
4. 360°

6-30. How many parallels of latitude are there on the surface of the Earth?
1. 180
2. 21,600
3. 1,296,000
4. An infinite number

6-31. The distance of a point north or south of the Equator measured along the point's meridian is called its
1. latitude
2. longitude
3. great circle distance
4. small circle distance

6-32. A ship that is at 0° latitude and 175°W longitude is at the
1. Equator
2. Greenwich meridian
3. North Pole
4. international date line

Learning Objective: Define a great circle and explain its significance in relation to navigation.

6-33. What is a circle whose plane passes through the center of the Earth?
1. Center plane
2. Bisecting plane
3. Great circle
4. Small circle

6-34. Which of the following lines of latitude and longitude are great circles?
1. All meridians and parallels
2. All meridians and the Equator
3. All parallels except the Equator
4. All parallels and the Greenwich meridian

6-35. If you stretch a piece of string against a globe of the world from Seattle to Tokyo, you will have laid out the shortest distance between these two cities. The string will have described an arc which is part of a
1. small circle
3. check line
3. great circle
4. meridian

6-36. What is the shortest distance between two points on the Earth's surface?
1. A straight line tangent to the Equator
2. A curved line as part of a great circle
3. A complete circle passing through both poles
4. A rhumb line parallel to any meridian

6-37. A minute of longitude is equal to 1 nautical mile when longitude is measured along
1. the Equator
2. any parallel
3. any parallel except the Equator
4. a small circle

Learning Objective: Describe various methods of measurement used in navigation.

6-38. Which of the following phrases correctly defines the term "knots"?
1. Nautical miles
2. Statute miles
3. Nautical miles per hour
4. Statute miles per hour

6-39. How many degrees are there between each of the old style compass points?
1. 5-1/2°
2. 11-1/4°
3. 32°
4. 360°

6-40. How many figures are used to express courses and bearings?
1. One
2. Two
3. Three
4. Four

6-41. When taking a bearing you would normally read it no closer than
1. 1/20th of a degree
2. 1/4th of a degree
3. 1/2 of a degree
4. 1 degree

6-42. True direction in the Navy is expressed in
1. degrees, measured clockwise from true north
2. degrees, measured counterclockwise from true north
3. points, measured clockwise from true north
4. points, measured counterclockwise from true north

6-43. What type of bearing indicates the angle between the line of sight to an object and the ship's head?
1. True
2. Magnetic
3. Relative
4. Geographic

6-44. What is the reciprocal of 330°?
1. 120°
2. 130°
3. 140°
4. 150°

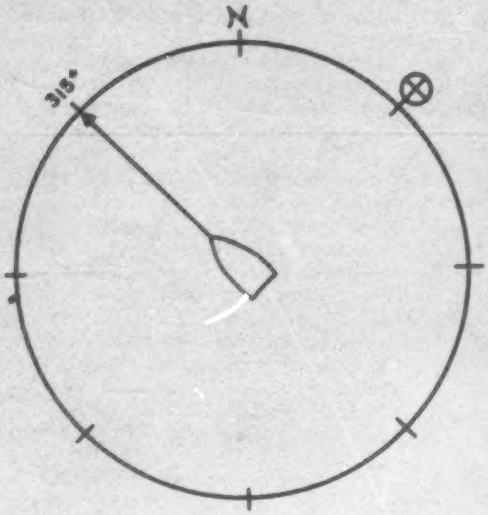


Figure 6A

● Refer to figure 6-A for items 6-45 and 6-46. Your ship is on a heading of 315° true and point ⓧ is 090° relative from you.

6-45. What is the true bearing of ⓧ?
1. 045°
2. 090°
3. 270°
4. 315°

6-46. How might a lookout report the location of ⓧ?
1. "On the starboard bow"
2. "On the starboard beam"
3. "On the port beam"
4. "On the port bow"

Learning Objective: Describe piloting methods and equipment used to determine and plot a ship's position.

6-47. On which of the following should you draw your plots for fixes?
1. Chart or overlay sheet
2. Plotting sheet or overlay sheet
3. Chart
4. Plotting sheet or chart

6-48. What instrument is used for measuring chart distances?
1. Hoey position plotter
2. Parallel rulers
3. Protractors
4. Dividers

6-49. Which of the following best describes a dead-reckoning (DR) position?
1. Exact position of ship
2. Accurate to one-half mile
3. An estimated position
4. All the above

6-50. What are the minimum plotting requirements for a fix?
1. A line of position
2. Three lines of position
3. Two parallel lines of position
4. Two intersecting lines of position

6-51. Several forces act to set a ship off its DR track. The direction in which these forces act is called
1. set
2. drift
3. doppler
4. trace interval

6-52. Which of the following types of underwater logs are used on Navy ships?
1. Pitotstatic
2. Electromechanical
3. Electromagnetic
4. All the above

6-53. Why is the rodmeter of the speed indicating log housed in the shaft when a ship enters shallow water?
1. To maintain watertight integrity
2. To obtain more accurate readings
3. To comply with security regulations
4. To protect the sword from injury

6-54. Which underwater log is the most accurate?
1. Electromagnetic
2. Pitotstatic
3. Electromechanical
4. Speedometer

6-55. What speed is measured by a log?
1. Actual speed over the ground
2. Speed through the water
3. Speed of drift in knots
4. Speed in miles per hour

6-56. Which of the following is a method of determining position and directing the movement of a vessel by reference to landmarks, navigational aids, or soundings?
1. Dead reckoning
2. Piloting
3. Running fixes
4. All the above

6-57. What do lines of position consist of?
1. Range
2. Bearings
3. Distance arcs
4. All the above

6-58. A nonmagnetic metal ring equipped with sighting devices and fitted over a gyro repeater is called a
1. synchronous alidade
2. telescopic alidade
3. bearing circle
4. stadimeter

6-59. What is meant when a ship is said to be "on the range"?
1. Two special landmarks are observed in line
2. The ship is at the intersection of two distance arcs
3. Radar ranges are being used
4. The ship is running a calibration range

6-60. How do you convert a relative bearing of a landmark to a true bearing?
1. Subtract ship's true heading
2. Add gyro error
3. Subtract gyro error
4. Add ship's true heading

6-61. When an observer takes a bearing on a terrestrial object, from which point and in what direction does he plot the bearing line of position?
1. From the ship, in a reciprocal direction
2. From the ship, in the direction of the landmark
3. From the landmark, in a reciprocal direction
4. From the landmark, in the direction of the bearing

6-62. What is a circular line of position whose radius is the distance from a landmark to the observer?
1. A tangent bearing
2. A distance arc
3. A tangent arc
4. A range

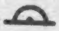
6-63. Which of the following is used to measure distances from your ship to others in a formation?
1. Alidade
2. Sextant
3. Stadimeter
4. Synchronous alidade

6-64. Where is the permanent record of a piloting track normally kept?
1. On an overlay sheet
2. On a plotting sheet
3. In a Bearing Record Book
4. On a chart

6-65. Which of the following plotting symbols indicates a dead-reckoned position?

1.

2.

3. 

4.

6-66. What do you do when three lines of position intersect to form a small triangle?
1. Take new bearings
2. Mark the fix at the intersection of the last two lines of position
3. Mark the fix at the intersection of the first two lines of position
4. Mark the fix at the center of the triangle

6-67. Which of the following methods of fixing a ship's position is the most accurate?
1. Taking a range and bearing to a single object
2. Establishing intersecting lines of position with bearings of two or more objects
3. Taking horizontal sextant angles between three fixed objects
4. Taking successive bearings of a single fixed object

6-68. What instrument is used to plot a position obtained by horizontal sextant angles?
1. Dead-reckoning tracer
2. Dividers
3. Parallel rulers
4. Three-arm protractor

6-69. The intersection of a line of position obtained from a bearing with an advanced line of position is called a(n)
1. estimated position
2. approximate fix
3. estimated fix
4. running fix

6-70. Locating the position of a ship by means of bow and beam bearings results in what type of fix?
1. A running fix
2. A simultaneous fix
3. A DR position
4. An estimated position

6-71. Which of the following devices is the most accurate for obtaining soundings in shallow depths?
1. Sounding machine
2. Hand lead
3. Fathometer
4. Pit log

6-72. A depth sounder sends a signal to the ocean floor which bounces off the floor and returns to the ship. How deep is the water if the signal returns to the ship 1 second after transmission?
1. 1200 ft
2. 2400 ft
3. 4800 ft
4. 9600 ft

6-73. Depths less than 400 feet can be most accurately established by the AN/UQN-1 when the recorder range is set to
1. 600 feet
2. 600 fathoms
3. 6000 fathoms
4. 600 or 6000 fathoms

6-74. In the flash count procedure for checking accuracy, the power supply frequency of a AN/UQN-1 may be checked by measuring the
1. voltage of the ship's power supply
2. difference between a sounding on the 0-600 scale and the 0-6000 scale
3. time elapsed while the stylus travels from 0 to 6000 fathoms
4. number of flashes per minute

6-75. Which of the following is NOT required to be recorded on each new roll of AN/UQN-1 recording paper?
1. Ship's name
2. Time zone
3. AN/UQN operator's name
4. Date

Assignment 7

Electronic Navigation; Celestial Navigation

Textbook, NAVEDTRA 10149-F: Pages 152-182

Learning Objective: Recognize general operating characteristics of loran.

7-1. What is one disadvantage of electronic navigation compared with celestial navigation?
1. It is subject to equipment failure
2. The objects being used to obtain a fix are not visible
3. The navigator must expose himself to the weather to take a fix
4. A fix cannot be obtained in adverse weather

7-2. In the loran system of navigation, a line of position is determined by the difference in
1. strength of a pair of transmitted signals
2. time of arrival of a pair of transmitted signals
3. frequency of a pair of transmitted signals
4. bearing of a pair of transmitted signals

7-3. How many loran transmitting stations are necessary to determine a single loran line of position?
1. One
2. Two
3. Three
4. Four

7-4. A line connecting the loran master and slave stations is known as the
1. delay line
2. baseline
3. baseline extension
4. reference line

7-5. How is the navigator warned that loran signals are unreliable?
1. A panel light glows red
2. The signals regularly shift to the right and back
3. There is a loud hum in the receiver
4. The master station transmits a coded signal

7-6. Assume you are navigating by the groundwaves (Tg) transmitted by loran-A during daylight hours. What is the maximum range at which you can expect to obtain a fix?
1. 100 to 200 nautical miles
2. 400 to 500 nautical miles
3. 700 to 800 nautical miles
4. 1300 to 1400 nautical miles

7-7. Radio waves that travel along the Earth's surface are known as
1. skipwaves
2. skywaves
3. groundwaves
4. reflection waves

7-8. Radio waves that travel toward outer space and then are reflected back to the Earth by the atmosphere are known as
1. spacewaves
2. skywaves
3. reflection waves
4. skipwaves

7-9. Time differences of master and secondary loran stations are measured in what increments?
1. Minutes
2. Microminutes
3. Microseconds
4. Seconds

7-10. Which of the following is included in the recording of a loran reading?
1. Ship's heading
2. Signal strength
3. Type of wave used
4. Atmospheric conditions

7-11. The notation "2L4" in the record of a loran reading refers to the
1. type of wave used
2. time of observation
3. rate of the pair of stations
4. type of trace interval

7-12. What is indicated by the notation "Ts" in the record of a loran reading?
1. The reading was unsatisfactory
2. The reading was obtained with skywaves
3. The reading was made with blinking signals
4. The recorded time of the reading was ship's time

7-13. What should you do if you obtain a loran reading and there are no lines plotted on your chart for that rate?
1. Take another reading on a different rate
2. Call the ETs to check the equipment
3. Consult Pub.No. 221 for information on the unplotted rate
4. Report the information to the DMAHC

Learning Objective: Recognize capabilities and limitations of radar as a navigational aid.

7-14. What is the minimum radar information required to establish a radar fix?
1. Three bearings and one range
2. Two bearings and two ranges
3. Two tangent bearings and one range to a small island
4. One bearing and one range to a single object

7-15. What feature of the PPI scope provides for the most exact determination of range?
1. Electronic cursor
2. Range rings
3. Range strobe
4. Hairline cursor

7-16. Which of the following methods of obtaining a radar fix is most accurate?
1. Cross bearings
2. Tangent bearings
3. Two or more ranges
4. Range and bearings of a single object

7-17. Which of the following objects will give the most accurate radar fix if a center bearing and a range are used?
1. Large island
2. Distant mountain
3. Straight shoreline
4. Small isolated rock

7-18. A radar fix is obtained by tangent bearings and the range to a single object. Where is the fix located?
1. At the intersection of the bearing lines
2. At the intersection of the range line and one bearing line
3. On the measured range and halfway between the bearing lines
4. In the middle of the triangle formed by the range line and the bearing lines

7-19. In piloting by radar, what compensation is applied to tangent bearings to allow for beam width?
1. Right and left tangent bearings are decreased by half the beam width
2. Right and left tangent bearings are increased by half the beam width
3. Right tangent bearings are decreased and left tangent bearings are increased by half the beam width
4. Right tangent bearings are increased and left tangent bearings are decreased by half the beam width

7-20. Assume that you are navigating into a harbor at night. You have the following points on radar:
A. channel buoy #1
B. a sandy beach cove
C. a lighthouse on a point of land
D. a large island, and
E. a small isolated rock
Which of the points listed would provide the most reliable navigational information?
1. A and B
2. B and E
3. C and E
4. D and A

7-21. The minimum difference in bearing whereby two objects at the same range can be discerned on a radarscope is called bearing resolution.

7-22. Bearing resolution can sometimes be improved by increasing the radar receiver gain.

7-23. The ability of radar to distinguish two targets on the same bearing is called
1. pulse width resolution
2. beam width resolution
3. bearing resolution
4. range resolution

Learning Objective: Describe basic concepts of satellite navigation system.

7-24. Doppler effect is demonstrated by the fact that the pitch of a train whistle will ______a______
Increase, decrease
as the train approaches and ______b______ after the
Increase, decrease
train passes.
1. (a) increase; (b) increase
2. (a) decrease; (b) decrease
3. (a) increase; (b) decrease
4. (a) decrease; (b) increase

7-25. When may a fix be obtained utilizing satellite information?
1. Nighttime only
2. Daytime only
3. At any time during a satellite pass
4. At any time

7-26. The satellites of the navigational satellite system receive corrective orbital data from the
1. tracking station
2. computing center
3. injection station
4. shipboard navigational equipment

7-27. How many times daily is corrective data sent to orbiting satellites?
1. 5 times daily
2. 4 times daily
3. 3 times daily
4. 2 times daily

7-28. Which of the following derives its high accuracy from time difference measurements of the pulsed signals, and the inherent stability of LF propagation?
1. Loran-A
2. Satellite navigation system
3. Radar
4. Loran-C

7-29. Who is responsible for the operation of loran-C stations?
1. U.S. Navy
2. Defense Mapping Agency
3. U.S. Coast Guard
4. U.S. Coast and Geodetic Survey

7-30. Which of the following is the center frequency of the loran-C system?
1. 85 kHz
2. 90 kHz
3. 95 kHz
4. 100 kHz

7-31. Loran-C chains are comprised of a master transmitting station; two or more secondary transmitting stations; and, if necessary, systems area monitor (SAMS) stations.

7-32. Which of the following designations indicate a loran-C secondary station?
1. W
2. X
3. Y
4. All the above

7-33. Which of the master station's pulses is used for visual identification?
1. 6th pulse
2. 7th pulse
3. 8th pulse
4. 9th pulse

7-34. What is the name of the very low-frequency radio navigation system that, when in full operation, will use only eight transmitting stations?
1. Loran-C
2. Shoran
3. Omega
4. None of the above

7-35. Omega signal phases can be predicted with enough accuracy to enable positioning within
1. 7 to 8 nautical miles
2. 5 to 6 nautical miles
3. 3 to 4 nautical miles
4. 1 to 2 nautical miles

7-36. What is the length, in nautical miles, of a representative baseline in the omega system?
1. 6000
2. 5000
3. 4000
4. 3000

7-37. Omega is a VLF, continuous-wave, time-shared radio navigation system with all stations transmitting at the same frequencies and in the same order.

7-38. To what time is the start of 10-second omega station cycle synchronized?
1. GMT (Greenwich mean time)
2. ZT (zone time)
3. UTC (coordinated universal time)
4. LMT (local mean time)

7-39. Each of the eight transmissions during the 10-second period of transmitting the complete sequence of signals is known as
1. omega run
2. time phase
3. baseline
4. time segment

● Select from the list below the equipment that matches the descriptions listed in items 7-40 through 7-45.

A. SINS
B. NAVDAC
C. Shoran
D. Star Tracker
E. Consol
F. Decca

7-40. A navigational system similar to loran that measures phase differences rather than time differences of the transmitted signals.
1. C
2. D
3. E
4. F

7-41. A system in which a series of dots and dashes are transmitted which are used to establish a fix.
1. A
2. B
3. E
4. F

7-42. Geographically fixed transmitters emit navigational signals when keyed by own ship's radar signal.
1. B
2. C
3. D
4. E

7-43. An optical telescope containing radio or infrared sensitive components that calculate altitude and azimuth data.
1. A
2. B
3. C
4. D

7-44. A self-contained system that provides a continuous, computed DR position display.
1. A
2. B
3. D
4. E

7-45. A memory bank of accurate navigational data.
1. B
2. C
3. E
4. F

Learning Objectives: Define terms associated with nautical astronomy and determine position by the use of the celestial sphere.

7-46. What is the phase of navigation, in which position is determined by the aid of heavenly bodies, called?
1. Electronic navigation
2. Piloting
3. Celestial navigation
4. All the above

7-47. The true shape of the Earth is that of an oblate spheroid; however, for purposes of celestial navigation its shape is considered to be that of a
1. paraboloid
2. prolate spheroid
3. cylinder
4. sphere

7-48. What is the name of a horizontal line in the system of coordinates used in locating objects on the celestial sphere?
1. Latitude
2. Longitude
3. Declination
4. Greenwich hour angle

7-49. What is the name of a vertical line in the system of coordinates used in locating objects on the celestial sphere?
1. Latitude
2. Longitude
3. Parallels
4. Greenwich hour angle

7-50. As a celestial body moves westward, the value of its GHA will
1. increase to 360°
2. decrease to 0°
3. increase to 180° and then decrease
4. remain approximately constant

7-51. What is the celestial reference point used to calculate sidereal hour angle?
1. Vernal equinox
2. Moon
3. Sun
4. Autumnal equinox

7-52. What is the polar distance, measured from the elevated North Pole, of a celestial body whose declination is 20°S?
1. 20°
2. 70°
3. 110°
4. 160°

7-53. In which of the following publications can declination of any navigational star be found for any day of the year?
1. Pub. No. 214
2. Nautical Almanac
3. Pub. No. 229
4. All the above

Learning Objective: Identify the time diagram and its uses in solving navigational problems.

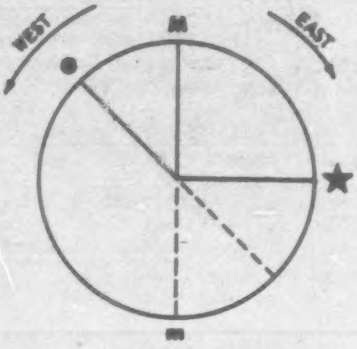


Figure 7A.--A time diagram

● Items 7-54 through 7-59 refer to time diagram in figure 7A.

7-54. When using the time diagram in figure 7A, the observer is assumed to be located outside the celestial sphere and at a point over
1. the sphere's North Pole
2. the sphere's South Pole
3. Greenwich, England
4. the first point of Aries

7-55. What is the approximate longitude of the observer?
1. 45°E
2. 45°W
3. 135°E
4. 135°W

7-56. What is the approximate GHA of the star?
1. 90°
2. 135°
3. 225°
4. 270°

7-57. What is the approximate LHA of the star?
1. 90°
2. 135°
3. 225°
4. 270°

7-58. What is the LHA of a star if the longitude of the observer is 35°W and the GHA of the star is 220°?
1. 105°
2. 185°
3. 220°
4. 255°

7-59. What is the approximate angle of the star shown in figure 7A?
1. 90°W
2. 90°E
3. 135°W
4. 135°E

Learning Objective: Identify LHA of a celestial body.

7-60. What is the GHA of a celestial body if its SHA is 100° and the GHA of the vernal equinox is 20°?
1. 20°
2. 80°
3. 100°
4. 120°

7-61. How is the LHA of a celestial body measured?
1. Westward or eastward from the local celestial meridian (M)
2. Westward or eastward from the hour circle of the body
3. Westward from the local celestial meridian (M)
4. Westward from the hour circle of the body

7-62. When a celestial body is west of the celestial meridian (M) of the observer, the meridian angle (t) of the body is equal to
1. the GHA of the body
2. the LHA of the body
3. 360° minus the LHA of the body
4. 360° minus the GHA of the body

Learning Objective: Explain basic celestial navigational terms. (This objective continued in assignment 8.)

7-63. What are the minimum plotting requirements for a celestial fix?
1. A celestial line of position that intersects a bearing
2. Two intersecting celestial lines of position
3. A course line intersected by a celestial line of position
4. Two intersecting azimuth lines

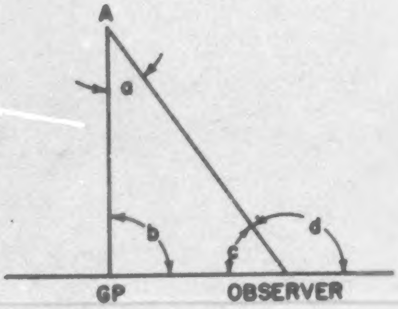


Figure 7B.--Navigating by a star

● Items 7-64 through 7-68 refer to figure 7B.

7-64. What angle in figure 7B represents the altitude of the star A?
1. a
2. b
3. c
4. d

7-65. If the distance from GP to the observer in figure 7B equals 2700 nautical miles, what is the altitude of the star at A?

1. 25°
2. 30°
3. 45°
4. 53°

7-66. What is the zenith distance of a celestial body if it is observed from a point 60 nautical miles from the GP of the body?

1. 1°
2. 30°
3. 60°
4. 89°

7-67. What is the altitude of a celestial body when viewed from a point located 5400 nautical miles from the GP of the body?

1. 0°
2. 36°
3. 54°
4. 90°

7-68. What is the circle of equal altitude for the star at A in figure 7B?

1. A circle with radius A to GP, origin at GP
2. A circle with radius GP to observer, origin at GP
3. A circle with radius GP to observer, origin at O
4. A circle with radius A to GP, origin at A

7-69. Although a line of position (LOP) is plotted as a straight line, it represents an arc of

1. the Equator
2. circle of equal altitude
3. a great circle
4. a meridian

7-70. In what publication will you find precomputed altitude and azimuth angles of navigational heavenly bodies?

1. Pub. No. 249
2. Nautical Almanac
3. Pub. No. 229
4. Pub. No. 9

Assignment 8

Celestial Navigation (continued); Tide and Currents

Textbook, NAVEDTRA 10149-F: Pages 182-208

Learning Objective (continued): Explain basic celestial navigational terms.

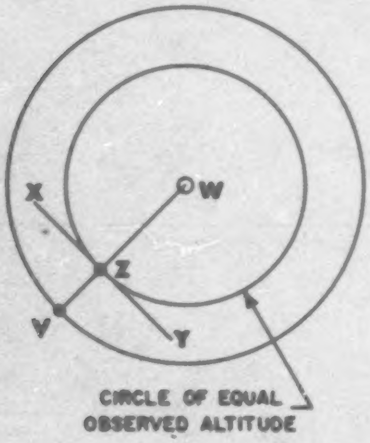


Figure 8A.--Celestial line of position

- Items 8-1 thru 8-4 refer to figure 8A.

8-1. What is represented by the line VZ?
1. Zenith distance
2. Observed azimuth
3. Altitude intercept
4. Line of position

8-2. What is represented by the line VZW?
1. The LOP
2. Azimuth line
3. Observed altitude
4. Altitude intercept

8-3. What line is the LOP?
1. ZW
2. ZV
3. WZV
4. XZY

8-4. Which of the following relationships is true of the observed and computed altitudes obtained in the situation?
1. Ho was less than Hc
2. Ho was greater than Hc
3. Ho was equal to Hc
4. Ho could have been either greater or less than Hc

8-5. What does the altitude intercept represent when a line of position is established by the observation of a star?
1. Distance run by the ship between two observations
2. Distance between the ship's position at the time of the observation and an assumed position along the azimuth line
3. Difference in the altitude of the star at different times
4. Point of intersection of two circles of equal altitude

8-6. What is another term for height of eye?
1. Parallax
2. Refraction
3. Semidiameter
4. Dip

8-7. Which of the following corrections are always subtracted from sextant readings?
1. Refraction and dip only
2. Refraction and semidiameter only
3. Dip and semidiameter only
4. Refraction, dip, and semidiameter

8-8. Which of the following types of correction is always added to the sextant reading to obtain a true altitude?
1. Semidiameter
2. Dip
3. Parallax
4. Refraction

8-9. Parallax correction allows for the difference between the
1. direction of a heavenly body as seen from some point on the Earth's surface and from the Earth's center
2. apparent and real motions of the Sun
3. center and lower limb of celestial bodies
4. visible horizon at the surface and visible horizon at the observer's height of eye

8-10. How is semidiameter correction applied to a sextant altitude?
1. Always added
2. Always subtracted
3. Added to a reading of the lower limb; subtracted from a reading of the upper limb
4. Added to a reading of the upper limb; subtracted from a reading of the lower limb

---

Learning Objective: Identify various stars and celestial bodies.

8-11. If a navigator is not familiar with navigational stars by sight, which of the following aids can he use to locate and identify the stars by which he wishes to establish one or more lines of position (LOP)?
1. Pub No. 214
2. Star finder (2102D)
3. Pub No. 216
4. The American Nautical Almanac

8-12. How many latitude degree intervals are there between each latitude template?
1. 5°
2. 10°
3. 15°
4. 20°

8-13. Latitude templates contain altitude and azimuth curves for determining the approximate altitudes and azimuths of celestial body.

8-14. The arrow on the latitude template that you secure on the star base of a star finder should be pointed toward the
1. local hour angle of Aries
2. Greenwich hour angle of the star whose altitude and azimuth you want to determine
3. meridian angle of the star whose altitude and azimuth you want to determine
4. sidereal hour angle of the star whose altitude and azimuth you want to determine

Learning Objective: Identify sextant components; describe sextant usage and care.

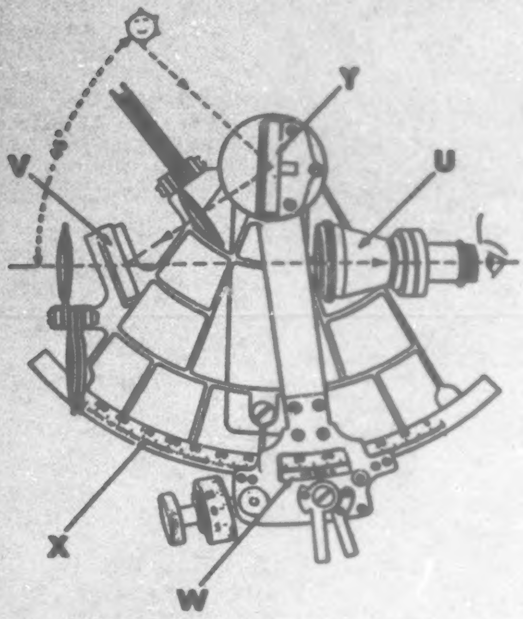


Figure 8B.--Marine sextant

- Items 8-15 thru 8-20 refer to figure 8B.

8-15. What is the principal function of a sextant in navigation?
1. Measuring the angle between a heavenly body and the visible horizon
2. Measuring ranges to other ships
3. Determining the true bearings of navigational aids
4. Determining the courses of the ships

8-16. What part of the sextant is parallel to the horizon glass when the index mark is at zero and there is no index correction?
1. U
2. V
3. X
4. Y

8-17. The index arm of the sextant pivots about the exact center of curvature of the part of sextant marked
1. U
2. W
3. X
4. Y

8-18. What part of the sextant is the horizon glass?
1. U
2. V
3. W
4. Y

8-19. How many degrees is the sextant index arm moved by one complete rotation of the micrometer drum?
1. 1°
2. 2°
3. 5°
4. 10°

8-20. The micrometer drum of the sextant is graduated in
1. seconds from 0 to 60
2. minutes from 0 to 60
3. half seconds from 0 to 180
4. half seconds from 0 to 20

8-21. When you are observing the Sun, what is the next step to carry out after you have trained the line of sight on the point of the horizon just below the Sun?
1. Raise the sextant until the line of sight touches the lower limb of the Sun
2. Swing the arc about the line of sight
3. Move the index arm until the Sun appears in the mirror
4. Move the micrometer drum to bring the direct and the reflected horizons in line

8-22. When the sextant is used to take a Sun sight, the reflected image of the Sun is adjusted until the
1. lower limb of the Sun touches the horizon
2. upper limb of the Sun touches the horizon
3. horizon bisects the images
4. image touches the dividing line of the horizon glass

8-23. What is the purpose of swinging the arc in an observation of the Sun?
1. To minimize parallax
2. To minimize semidiameter error
3. To ensure that the lower limb of the Sun is tangent to the horizon
4. To ensure that the reading taken is from the point of the horizon directly below the Sun

8-24. You have sighted on the horizon to determine the index correction of a sextant. The index mark falls on the arc just to the left of the 0° line. What is the index correction if the drum and vernier read 9.4'?
1. (+)50.6;
2. (+)9.4'
3. (-)50.6'
4. (-)9.4'

8-25. Which of the following cleaning agents is used to clean the mirror or glass surface of a sextant?
1. Saltwater
2. Alcohol
3. Ammonia
4. Soapy water

8-26. Which of the following cleaning agents is used to clean the limb and the vernier of the sextant?
1. Brass polish
2. Alcohol
3. Ammonia
4. Soapy water

Learning Objective: Using the given information and the appropriate publications, work sight problems.

8-27. Which of the following symbols represents the altitude of a celestial body read directly from the sextant?
1. Hs
2. Ho
3. Hc
4. t

8-28. What values must be known to use Pub No. 229 in finding the computed altitude and azimuth of a celestial body?
1. Latitude, declination, and local hour angle
2. Latitude, longitude, and declination only
3. Latitude, longitude, and local hour angle
4. Latitude, longitude, declination, and local hour angle

8-29. Why do you have to know the GMT to work a sight problem for a celestial body?
1. To find the SHA of that celestial body
2. To find the GHA of the first point of Aries
3. To find declination
4. To find computed altitude

8-30. If your longitude is 93°W and the GHA of the celestial body you are sighting on is 108°, what is the LHA for that body?
1. 15°E
2. 15°W
3. 54°E
4. 54°W

8-31. What longitude should you use for an AP when Pub No. 229 is used to determine an LOP?
1. Longitude corresponding to LAT
2. Longitude corresponding to ZT
3. Longitude computed from the actual DR position
4. Longitude closest to the DR longitude that will give an LHA in whole degrees

8-32. What is the minimum number of volumes of Pub No. 229 that the navigator must have to be fully prepared to compute star altitudes from any position on either side of the equator?
1. Four
2. Five
3. Six
4. Seven

NOTE: Before answering items 8-33 thru 8-44, carefully review pages 189 thru 192 of your testbook, and figures 8C thru 8G.

ALTITUDE CORRECTION TABLES 10°-90°—SUN, STARS, PLANETS

OCT.—MAR. SUN APR.—SEPT.

App. Alt.	Lower Limb	Upper Limb	App. Alt.	Lower Limb	Upper Limb
° ′	′	′	° ′	′	′
9 34			9 39		
	+10·8	−21·5		+10·6	−21·2
9 45			9 51		
	+10·9	−21·4		+10·7	−21·1
9 56			10 03		
	+11·0	−21·3		+10·8	−21·0
10 08			10 15		
	+11·1	−21·2		+10·9	−20·9
10 21			10 27		
	+11·2	−21·1		+11·0	−20·8
10 34			10 40		
	+11·3	−21·0		+11·1	−20·7
10 47			10 54		
	+11·4	−20·9		+11·2	−20·6
11 01			11 08		
	+11·5	−20·8		+11·3	−20·5
11 15			11 23		
	+11·6	−20·7		+11·4	−20·4
11 30			11 38		
	+11·7	−20·6		+11·5	−20·3
11 46			11 54		
	+11·8	−20·5		+11·6	−20·2
12 02			12 10		
	+11·9	−20·4		+11·7	−20·1
12 19			12 28		
	+12·0	−20·3		+11·8	−20·0
12 37			12 46		
	+12·1	−20·2		+11·9	−19·9
12 55			13 05		
	+12·2	−20·1		+12·0	−19·8
13 14			13 24		
	+12·3	−20·0		+12·1	−19·7
13 35			13 45		
	+12·4	−19·9		+12·2	−19·6
13 56			14 07		
	+12·5	−19·8		+12·3	−19·5
14 18			14 30		
	+12·6	−19·7		+12·4	−19·4
14 42			14 54		
	+12·7	−19·6		+12·5	−19·3
15 06			15 19		
	+12·8	−19·5		+12·6	−19·2
15 32			15 46		
	+12·9	−19·4		+12·7	−19·1
15 59			16 14		
	+13·0	−19·3		+12·8	−19·0
16 28			16 44		
	+13·1	−19·2		+12·9	−18·9
16 59			17 15		
	+13·2	−19·1		+13·0	−18·8
17 32			17 48		
	+13·3	−19·0		+13·1	−18·7
18 06			18 24		
	+13·4	−18·9		+13·2	−18·6
18 42			19 01		
	+13·5	−18·8		+13·3	−18·5
19 21			19 42		
	+13·6	−18·7		+13·4	−18·4
20 03			20 25		
	+13·7	−18·6		+13·5	−18·3
20 48			21 11		
	+13·8	−18·5		+13·6	−18·2
21 35			22 00		
	+13·9	−18·4		+13·7	−18·1
22 26			22 54		
	+14·0	−18·3		+13·8	−18·0
23 22			23 51		
	+14·1	−18·2		+13·9	−17·9
24 21			24 53		
	+14·2	−18·1		+14·0	−17·8
25 26			26 00		
	+14·3	−18·0		+14·1	−17·7
26 36			27 13		
	+14·4	−17·9		+14·2	−17·6
27 52			28 33		
	+14·5	−17·8		+14·3	−17·5
29 15			30 00		
	+14·6	−17·7		+14·4	−17·4
30 46			31 35		
	+14·7	−17·6		+14·5	−17·3
32 26			33 20		
	+14·8	−17·5		+14·6	−17·2
34 17			35 17		
	+14·9	−17·4		+14·7	−17·1
36 20			37 26		
	+15·0	−17·3		+14·8	−17·0
38 36			39 50		
	+15·1	−17·2		+14·9	−16·9
41 08			42 31		
	+15·2	−17·1		+15·0	−16·8
43 59			45 31		
	+15·3	−17·0		+15·1	−16·7
47 10			48 55		
	+15·4	−16·9		+15·2	−16·6
50 46			52 44		
	+15·5	−16·8		+15·3	−16·5
54 49			57 02		
	+15·6	−16·7		+15·4	−16·4
59 23			61 51		
	+15·7	−16·6		+15·5	−16·3
64 30			67 17		
	+15·8	−16·5		+15·6	−16·2
70 12			73 16		
	+15·9	−16·4		+15·7	−16·1
76 26			79 43		
	+16·0	−16·3		+15·8	−16·0
83 05			86 32		
	+16·1	−16·2		+15·9	−15·9
90 00			90 00		

STARS AND PLANETS

App. Alt.	Corrn
° ′	′
9 56	
	−5·3
10 08	
	−5·2
10 20	
	−5·1
10 33	
	−5·0
10 46	
	−4·9
11 00	
	−4·8
11 14	
	−4·7
11 29	
	−4·6
11 45	
	−4·5
12 01	
	−4·4
12 18	
	−4·3
12 35	
	−4·2
12 54	
	−4·1
13 13	
	−4·0
13 33	
	−3·9
13 54	
	−3·8
14 16	
	−3·7
14 40	
	−3·6
15 04	
	−3·5
15 30	
	−3·4
15 57	
	−3·3
16 26	
	−3·2
16 56	
	−3·1
17 28	
	−3·0
18 02	
	−2·9
18 38	
	−2·8
19 17	
	−2·7
19 58	
	−2·6
20 42	
	−2·5
21 28	
	−2·4
22 19	
	−2·3
23 13	
	−2·2
24 11	
	−2·1
25 14	
	−2·0
26 22	
	−1·9
27 36	
	−1·8
28 56	
	−1·7
30 24	
	−1·6
32 00	
	−1·5
33 45	
	−1·4
35 40	
	−1·3
37 48	
	−1·2
40 08	
	−1·1
42 44	
	−1·0
45 36	
	−0·9
48 47	
	−0·8
52 18	
	−0·7
56 11	
	−0·6
60 28	
	−0·5
65 08	
	−0·4
70 11	
	−0·3
75 34	
	−0·2
81 13	
	−0·1
87 03	
	0·0
90 00	

App. Alt.	Additional Corrn
1975	
VENUS	
Jan. 1 – June 7	
° 0	
	+ 0·1
42	
June 8 – July 21	
° 0	
	+ 0·3
46	
July 22 – Aug. 6	
° 0	
	+ 0·4
11	
	+ 0·5
41	
Aug. 7 – Aug. 15	
° 0	
	+ 0·5
6	
	+ 0·6
20	
	+ 0·7
31	
Aug. 16 – Sept. 10	
° 0	
	+ 0·6
4	
	+ 0·7
12	
	+ 0·8
22	
Sept. 11 – Sept. 19	
° 0	
	+ 0·5
6	
	+ 0·6
20	
	+ 0·7
31	
Sept. 20 – Oct. 5	
° 0	
	+ 0·4
11	
	+ 0·5
41	
Oct. 6 – Nov. 22	
° 0	
	+ 0·3
46	
Nov. 23 – Dec. 31	
° 0	
	+ 0·1
42	
MARS	
Jan. 1 – Sept. 8	
° 0	
	+ 0·1
60	
Sept. 9 – Nov. 22	
° 0	
	+ 0·2
41	
	+ 0·1
75	
Nov. 23 – Dec. 31	
° 0	
	+ 0·3
34	
	+ 0·2
60	
	+ 0·1
80	

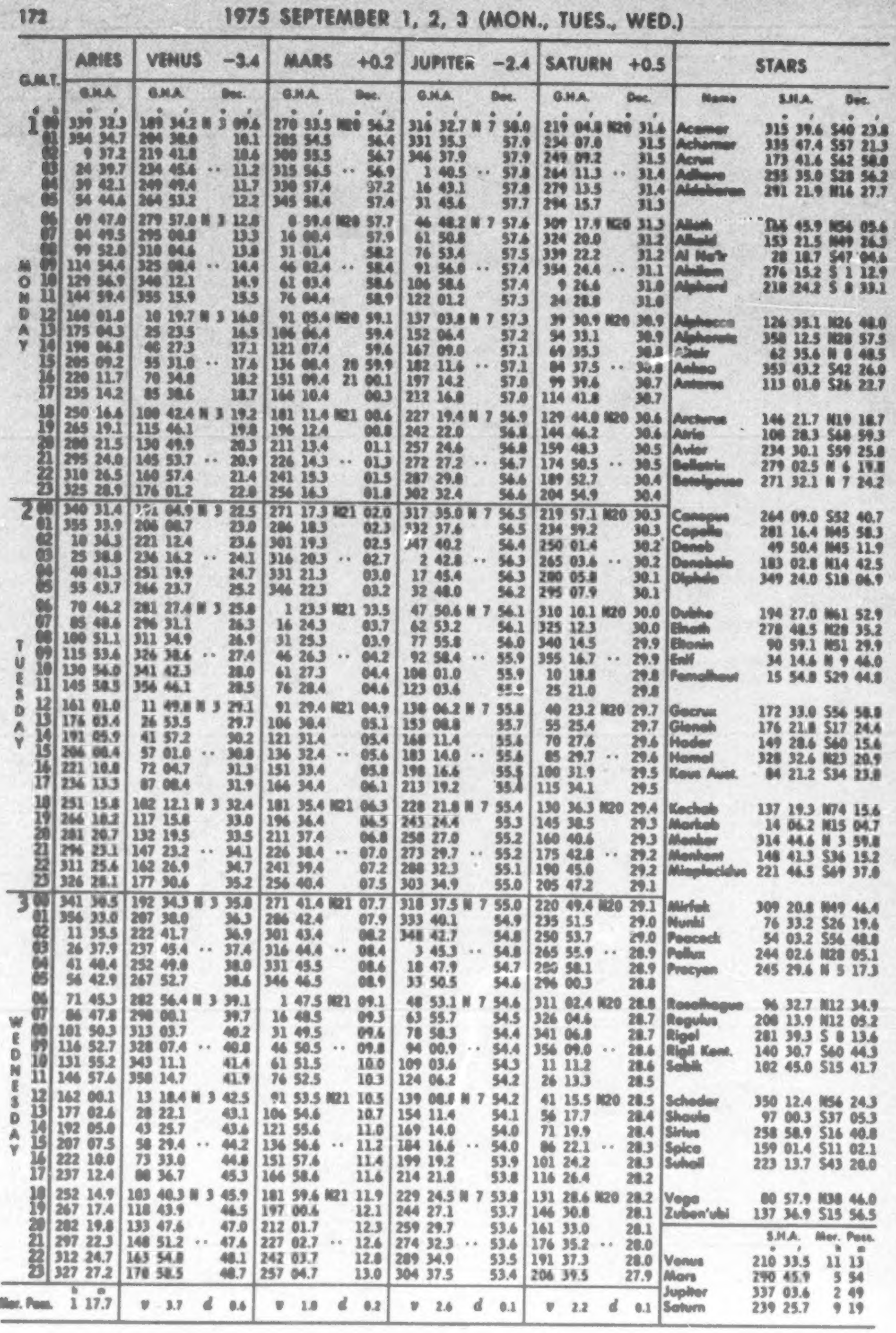
DIP

Ht. of Eye	Corrn	Ht. of Eye
m	′	ft.
2·4		8·0
	−2·8	
2·6		8·6
	−2·9	
2·8		9·2
	−3·0	
3·0		9·8
	−3·1	
3·2		10·5
	−3·2	
3·4		11·2
	−3·3	
3·6		11·9
	−3·4	
3·8		12·6
	−3·5	
4·0		13·3
	−3·6	
4·3		14·1
	−3·7	
4·5		14·9
	−3·8	
4·7		15·7
	−3·9	
5·0		16·5
	−4·0	
5·2		17·4
	−4·1	
5·5		18·3
	−4·2	
5·8		19·1
	−4·3	
6·1		20·1
	−4·4	
6·3		21·0
	−4·5	
6·6		22·0
	−4·6	
6·9		22·9
	−4·7	
7·2		23·9
	−4·8	
7·5		24·9
	−4·9	
7·9		26·0
	−5·0	
8·2		27·1
	−5·1	
8·5		28·1
	−5·2	
8·8		29·2
	−5·3	
9·2		30·4
	−5·4	
9·5		31·5
	−5·5	
9·9		32·7
	−5·6	
10·3		33·9
	−5·7	
10·6		35·1
	−5·8	
11·0		36·3
	−5·9	
11·4		37·6
	−6·0	
11·8		38·9
	−6·1	
12·2		40·1
	−6·2	
12·6		41·5
	−6·3	
13·0		42·8
	−6·4	
13·4		44·2
	−6·5	
13·8		45·5
	−6·6	
14·2		46·9
	−6·7	
14·7		48·4
	−6·8	
15·1		49·8
	−6·9	
15·5		51·3
	−7·0	
16·0		52·8
	−7·1	
16·5		54·3
	−7·2	
16·9		55·8
	−7·3	
17·4		57·4
	−7·4	
17·9		58·9
	−7·5	
18·4		60·5
	−7·6	
18·8		62·1
	−7·7	
19·3		63·8
	−7·8	
19·8		65·4
	−7·9	
20·4		67·1
	−8·0	
20·9		68·8
	−8·1	
21·4		70·5

Ht. of Eye	Corrn
m	′
1·0	− 1·8
1·5	− 2·2
2·0	− 2·5
2·5	− 2·8
3·0	− 3·0
See table ←	
m	′
20	− 7·9
22	− 8·3
24	− 8·6
26	− 9·0
28	− 9·3
30	− 9·6
32	− 10·0
34	− 10·3
36	− 10·6
38	− 10·8
40	− 11·1
42	− 11·4
44	− 11·7
46	− 11·9
48	− 12·2
ft.	′
2	− 1·4
4	− 1·9
6	− 2·4
8	− 2·7
10	− 3·1
See table ←	
ft.	′
70	− 8·1
75	− 8·4
80	− 8·7
85	− 8·9
90	− 9·2
95	− 9·5
100	− 9·7
105	− 9·9
110	− 10·2
115	− 10·4
120	− 10·6
125	− 10·8
130	− 11·1
135	− 11·3
140	− 11·5
145	− 11·7
150	− 11·9
155	− 12·1

App. Alt. = Apparent altitude = Sextant altitude corrected for index error and dip.
For daylight observations of Venus, see page 260.

Figure 8C.--An excerpt from "The Nautical Almanac"



172 1975 SEPTEMBER 1, 2, 3 (MON., TUES., WED.)

G.M.T.		ARIES	VENUS −3.4		MARS +0.2		JUPITER −2.4		SATURN +0.5	
		G.H.A.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.
	d h	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
MONDAY	1 00	339 32.3	189 34.2	N 3 09.6	270 53.5	N20 56.2	316 32.7	N 7 58.0	219 04.8	N20 31.6
	01	354 34.7	204 38.0	10.1	285 54.5	56.4	331 35.3	57.9	234 07.0	31.5
	02	9 37.2	219 41.8	10.6	300 55.5	56.7	346 37.9	57.9	249 09.2	31.5
	03	24 39.7	234 45.6	·· 11.2	315 56.5	·· 56.9	1 40.5	·· 57.8	264 11.3	·· 31.4
	04	39 42.1	249 49.4	11.7	330 57.4	57.2	16 43.1	57.8	279 13.5	31.4
	05	54 44.6	264 53.2	12.2	345 58.4	57.4	31 45.6	57.7	294 15.7	31.3
	06	69 47.0	279 57.0	N 3 12.8	0 59.4	N20 57.7	46 48.2	N 7 57.6	309 17.9	N20 31.3
	07	84 49.5	295 00.8	13.3	16 00.4	57.9	61 50.8	57.6	324 20.0	31.2
	08	99 52.0	310 04.6	13.8	31 01.4	58.2	76 53.4	57.5	339 22.2	31.2
	09	114 54.4	325 08.4	·· 14.4	46 02.4	·· 58.4	91 56.0	·· 57.4	354 24.4	·· 31.1
	10	129 56.9	340 12.1	14.9	61 03.4	58.6	106 58.6	57.4	9 26.6	31.0
	11	144 59.4	355 15.9	15.5	76 04.4	58.9	122 01.2	57.3	24 28.8	31.0
	12	160 01.8	10 19.7	N 3 16.0	91 05.4	N20 59.1	137 03.8	N 7 57.3	39 30.9	N20 30.9
	13	175 04.3	25 23.5	16.5	106 06.4	59.4	152 06.4	57.2	54 33.1	30.9
	14	190 06.8	40 27.3	17.1	121 07.4	59.6	167 09.0	57.1	69 35.3	30.8
	15	205 09.2	55 31.0	·· 17.6	136 08.4	20 59.9	182 11.6	·· 57.1	84 37.5	·· 30.8
	16	220 11.7	70 34.8	18.2	151 09.4	21 00.1	197 14.2	57.0	99 39.6	30.7
	17	235 14.2	85 38.6	18.7	166 10.4	00.3	212 16.8	57.0	114 41.8	30.7
	18	250 16.6	100 42.4	N 3 19.2	181 11.4	N21 00.6	227 19.4	N 7 56.9	129 44.0	N20 30.6
	19	265 19.1	115 46.1	19.8	196 12.4	00.8	242 22.0	56.8	144 46.2	30.6
	20	280 21.5	130 49.9	20.3	211 13.4	01.1	257 24.6	56.8	159 48.3	30.5
	21	295 24.0	145 53.7	·· 20.9	226 14.3	·· 01.3	272 27.2	·· 56.7	174 50.5	·· 30.5
	22	310 26.5	160 57.4	21.4	241 15.3	01.5	287 29.8	56.6	189 52.7	30.4
	23	325 28.9	176 01.2	22.0	256 16.3	01.8	302 32.4	56.6	204 54.9	30.4
TUESDAY	2 00	340 31.4	191 04.9	N 3 22.5	271 17.3	N21 02.0	317 35.0	N 7 56.5	219 57.1	N20 30.3
	01	355 33.9	206 08.7	23.0	286 18.3	02.3	332 37.6	56.5	234 59.2	30.3
	02	10 36.3	221 12.4	23.6	301 19.3	02.5	347 40.2	56.4	250 01.4	30.2
	03	25 38.8	236 16.2	·· 24.1	316 20.3	·· 02.7	2 42.8	·· 56.3	265 03.6	·· 30.2
	04	40 41.3	251 19.9	24.7	331 21.3	03.0	17 45.4	56.3	280 05.8	30.1
	05	55 43.7	266 23.7	25.2	346 22.3	03.2	32 48.0	56.2	295 07.9	30.1
	06	70 46.2	281 27.4	N 3 25.8	1 23.3	N21 03.5	47 50.6	N 7 56.1	310 10.1	N20 30.0
	07	85 48.6	296 31.1	26.3	16 24.3	03.7	62 53.2	56.1	325 12.3	30.0
	08	100 51.1	311 34.9	26.9	31 25.3	03.9	77 55.8	56.0	340 14.5	29.9
	09	115 53.6	326 38.6	·· 27.4	46 26.3	·· 04.2	92 58.4	·· 55.9	355 16.7	·· 29.9
	10	130 56.0	341 42.3	28.0	61 27.3	04.4	108 01.0	55.9	10 18.8	29.8
	11	145 58.5	356 46.1	28.5	76 28.4	04.6	123 03.6	55.8	25 21.0	29.8
	12	161 01.0	11 49.8	N 3 29.1	91 29.4	N21 04.9	138 06.2	N 7 55.8	40 23.2	N20 29.7
	13	176 03.4	26 53.5	29.7	106 30.4	05.1	153 08.8	55.7	55 25.4	29.7
	14	191 05.9	41 57.2	30.2	121 31.4	05.4	168 11.4	55.6	70 27.6	29.6
	15	206 08.4	57 01.0	·· 30.8	136 32.4	·· 05.6	183 14.0	·· 55.6	85 29.7	·· 29.6
	16	221 10.8	72 04.7	31.3	151 33.4	05.8	198 16.6	55.5	100 31.9	29.5
	17	236 13.3	87 08.4	31.9	166 34.4	06.1	213 19.2	55.4	115 34.1	29.5
	18	251 15.8	102 12.1	N 3 32.4	181 35.4	N21 06.3	228 21.8	N 7 55.4	130 36.3	N20 29.4
	19	266 18.2	117 15.8	33.0	196 36.4	06.5	243 24.4	55.3	145 38.5	29.3
	20	281 20.7	132 19.5	33.5	211 37.4	06.8	258 27.0	55.2	160 40.6	29.3
	21	296 23.1	147 23.2	·· 34.1	226 38.4	·· 07.0	273 29.7	·· 55.2	175 42.8	·· 29.2
	22	311 25.6	162 26.9	34.7	241 39.4	07.2	288 32.3	55.1	190 45.0	29.2
	23	326 28.1	177 30.6	35.2	256 40.4	07.5	303 34.9	55.0	205 47.2	29.1
WEDNESDAY	3 00	341 30.5	192 34.3	N 3 35.8	271 41.4	N21 07.7	318 37.5	N 7 55.0	220 49.4	N20 29.1
	01	356 33.0	207 38.0	36.3	286 42.4	07.9	333 40.1	54.9	235 51.5	29.0
	02	11 35.5	222 41.7	36.9	301 43.4	08.2	348 42.7	54.8	250 53.7	29.0
	03	26 37.9	237 45.4	·· 37.4	316 44.4	·· 08.4	3 45.3	·· 54.8	265 55.9	·· 28.9
	04	41 40.4	252 49.0	38.0	331 45.5	08.6	18 47.9	54.7	280 58.1	28.9
	05	56 42.9	267 52.7	38.6	346 46.5	08.9	33 50.5	54.6	296 00.3	28.8
	06	71 45.3	282 56.4	N 3 39.1	1 47.5	N21 09.1	48 53.1	N 7 54.6	311 02.4	N20 28.8
	07	86 47.8	298 00.1	39.7	16 48.5	09.3	63 55.7	54.5	326 04.6	28.7
	08	101 50.3	313 03.7	40.2	31 49.5	09.6	78 58.3	54.4	341 06.8	28.7
	09	116 52.7	328 07.4	·· 40.8	46 50.5	·· 09.8	94 00.9	·· 54.4	356 09.0	·· 28.6
	10	131 55.2	343 11.1	41.4	61 51.5	10.0	109 03.6	54.3	11 11.2	28.6
	11	146 57.6	358 14.7	41.9	76 52.5	10.3	124 06.2	54.2	26 13.3	28.5
	12	162 00.1	13 18.4	N 3 42.5	91 53.5	N21 10.5	139 08.8	N 7 54.2	41 15.5	N20 28.5
	13	177 02.6	28 22.1	43.1	106 54.6	10.7	154 11.4	54.1	56 17.7	28.4
	14	192 05.0	43 25.7	43.6	121 55.6	11.0	169 14.0	54.0	71 19.9	28.4
	15	207 07.5	58 29.4	·· 44.2	136 56.6	·· 11.2	184 16.6	·· 54.0	86 22.1	·· 28.3
	16	222 10.0	73 33.0	44.8	151 57.6	11.4	199 19.2	53.9	101 24.2	28.3
	17	237 12.4	88 36.7	45.3	166 58.6	11.6	214 21.8	53.8	116 26.4	28.2
	18	252 14.9	103 40.3	N 3 45.9	181 59.6	N21 11.9	229 24.5	N 7 53.8	131 28.6	N20 28.2
	19	267 17.4	118 43.9	46.5	197 00.6	12.1	244 27.1	53.7	146 30.8	28.1
	20	282 19.8	133 47.6	47.0	212 01.7	12.3	259 29.7	53.6	161 33.0	28.1
	21	297 22.3	148 51.2	·· 47.6	227 02.7	·· 12.6	274 32.3	·· 53.6	176 35.2	·· 28.0
	22	312 24.7	163 54.8	48.1	242 03.7	12.8	289 34.9	53.5	191 37.3	28.0
	23	327 27.2	178 58.5	48.7	257 04.7	13.0	304 37.5	53.4	206 39.5	27.9
Mer. Pass.		h m 1 17.7	v 3.7	d 0.6	v 1.0	d 0.2	v 2.6	d 0.1	v 2.2	d 0.1

STARS		
Name	S.H.A.	Dec.
	° ′	° ′
Acamar	315 39.6	S40 23.8
Achernar	335 47.4	S57 21.3
Acrux	173 41.6	S62 58.8
Adhara	255 35.0	S28 56.2
Aldebaran	291 21.9	N16 27.7
Alioth	166 45.9	N56 05.6
Alkaid	153 21.5	N49 26.3
Al Na'ir	28 18.7	S47 04.6
Alnilam	276 15.2	S 1 12.9
Alphard	218 24.2	S 8 33.1
Alphecca	126 35.1	N26 48.0
Alpheratz	358 12.5	N28 57.5
Altair	62 35.6	N 8 48.5
Ankaa	353 43.2	S42 26.0
Antares	113 01.0	S26 22.7
Arcturus	146 21.7	N19 18.7
Atria	108 28.3	S68 59.3
Avior	234 30.1	S59 25.8
Bellatrix	279 02.5	N 6 19.8
Betelgeuse	271 32.1	N 7 24.2
Canopus	264 09.0	S52 40.7
Capella	281 16.4	N45 58.3
Deneb	49 50.4	N45 11.9
Denebola	183 02.8	N14 42.5
Diphda	349 24.0	S18 06.9
Dubhe	194 27.0	N61 52.9
Elnath	278 48.5	N28 35.2
Eltanin	90 59.1	N51 29.9
Enif	34 14.6	N 9 46.0
Fomalhaut	15 54.8	S29 44.8
Gacrux	172 33.0	S56 58.8
Gienah	176 21.8	S17 24.4
Hadar	149 28.6	S60 15.6
Hamal	328 32.6	N23 20.9
Kaus Aust.	84 21.2	S34 23.8
Kochab	137 19.3	N74 15.6
Markab	14 06.2	N15 04.7
Menkar	314 44.6	N 3 59.8
Menkent	148 41.3	S36 15.2
Miaplacidus	221 46.5	S69 37.0
Mirfak	309 20.8	N49 46.4
Nunki	76 33.2	S26 19.6
Peacock	54 03.2	S56 48.8
Pollux	244 02.6	N28 05.1
Procyon	245 29.6	N 5 17.3
Rasalhague	96 32.7	N12 34.9
Regulus	208 13.9	N12 05.2
Rigel	281 39.3	S 8 13.6
Rigil Kent.	140 30.7	S60 44.3
Sabik	102 45.0	S15 41.7
Schedar	350 12.4	N56 24.3
Shaula	97 00.3	S37 05.3
Sirius	258 58.9	S16 40.8
Spica	159 01.4	S11 02.1
Suhail	223 13.7	S43 20.0
Vega	80 57.9	N38 46.0
Zuben'ubi	137 36.9	S15 56.5

	S.H.A.	Mer. Pass.
	° ′	h m
Venus	210 33.5	11 13
Mars	290 45.9	5 54
Jupiter	337 03.6	2 49
Saturn	239 25.7	9 19

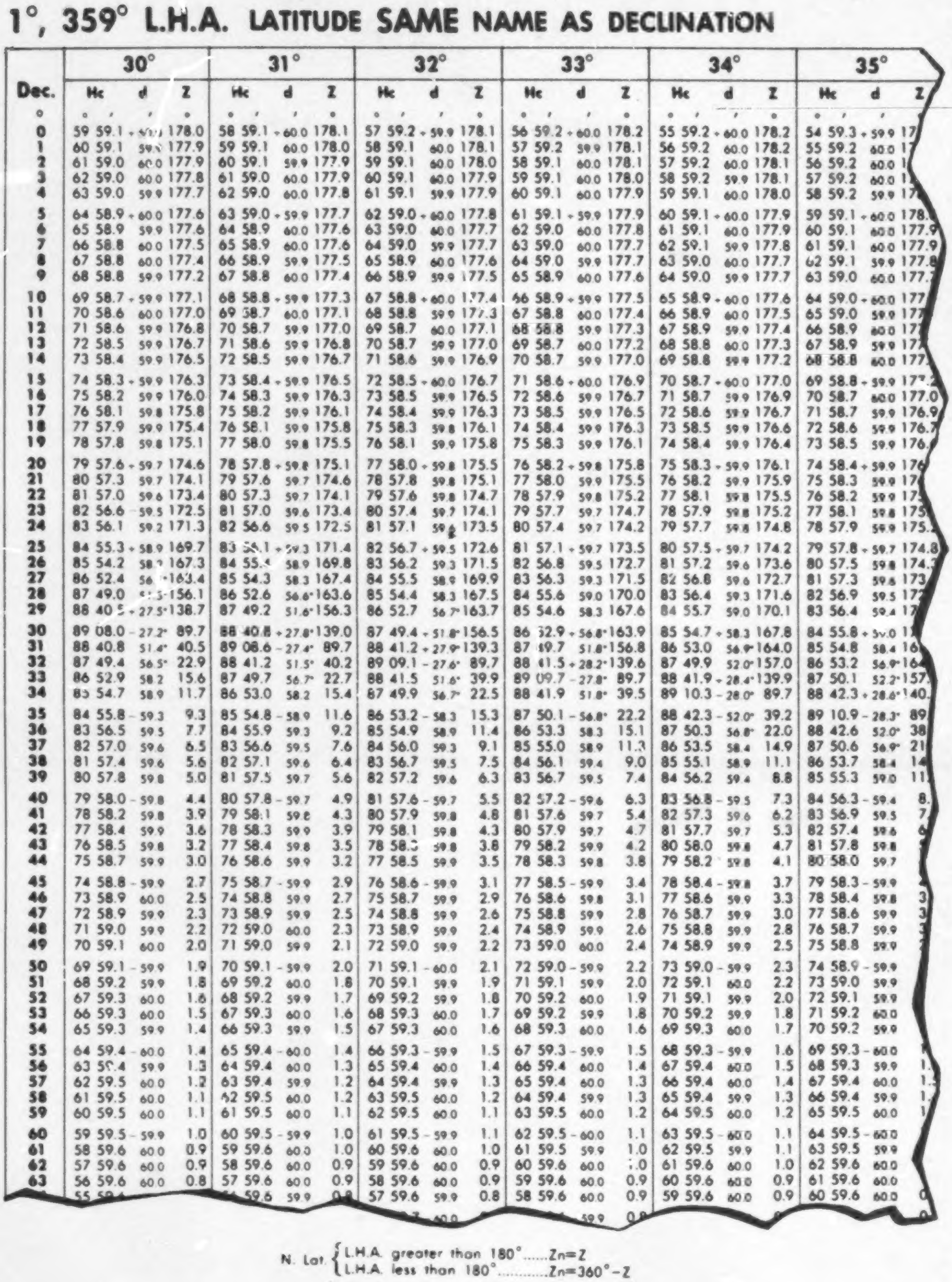
Figure 8D.--An excerpt from "The Nautical Almanac"

26ᵐ INCREMENTS AND CORRECTIONS **27ᵐ**

26ᵐ	SUN PLANETS	ARIES	MOON	v or d	Corrⁿ	v or d	Corrⁿ	v or d	Corrⁿ
s	° ′	° ′	° ′	′	′	′	′	′	′
00	6 30·0	6 31·1	6 12·2	0·0	0·0	6·0	2·7	12·0	5·3
01	6 30·3	6 31·3	6 12·5	0·1	0·0	6·1	2·7	12·1	5·3
02	6 30·5	6 31·6	6 12·7	0·2	0·1	6·2	2·7	12·2	5·4
03	6 30·8	6 31·8	6 12·9	0·3	0·1	6·3	2·8	12·3	5·4
04	6 31·0	6 32·1	6 13·2	0·4	0·2	6·4	2·8	12·4	5·5
05	6 31·3	6 32·3	6 13·4	0·5	0·2	6·5	2·9	12·5	5·5
06	6 31·5	6 32·6	6 13·7	0·6	0·3	6·6	2·9	12·6	5·6
07	6 31·8	6 32·8	6 13·9	0·7	0·3	6·7	3·0	12·7	5·6
08	6 32·0	6 33·1	6 14·1	0·8	0·4	6·8	3·0	12·8	5·7
09	6 32·3	6 33·3	6 14·4	0·9	0·4	6·9	3·0	12·9	5·7
10	6 32·5	6 33·6	6 14·6	1·0	0·4	7·0	3·1	13·0	5·7
11	6 32·8	6 33·8	6 14·9	1·1	0·5	7·1	3·1	13·1	5·8
12	6 33·0	6 34·1	6 15·1	1·2	0·5	7·2	3·2	13·2	5·8
13	6 33·3	6 34·3	6 15·3	1·3	0·6	7·3	3·2	13·3	5·9
14	6 33·5	6 34·6	6 15·6	1·4	0·6	7·4	3·3	13·4	5·9
15	6 33·8	6 34·8	6 15·8	1·5	0·7	7·5	3·3	13·5	6·0
16	6 34·0	6 35·1	6 16·1	1·6	0·7	7·6	3·4	13·6	6·0
17	6 34·3	6 35·3	6 16·3	1·7	0·8	7·7	3·4	13·7	6·1
18	6 34·5	6 35·6	6 16·5	1·8	0·8	7·8	3·4	13·8	6·1
19	6 34·8	6 35·8	6 16·8	1·9	0·8	7·9	3·5	13·9	6·1
20	6 35·0	6 36·1	6 17·0	2·0	0·9	8·0	3·5	14·0	6·2
21	6 35·3	6 36·3	6 17·2	2·1	0·9	8·1	3·6	14·1	6·2
22	6 35·5	6 36·6	6 17·5	2·2	1·0	8·2	3·6	14·2	6·3
23	6 35·8	6 36·8	6 17·7	2·3	1·0	8·3	3·7	14·3	6·3
24	6 36·0	6 37·1	6 18·0	2·4	1·1	8·4	3·7	14·4	6·4
25	6 36·3	6 37·3	6 18·2	2·5	1·1	8·5	3·8	14·5	6·4
26	6 36·5	6 37·6	6 18·4	2·6	1·1	8·6	3·8	14·6	6·4
27	6 36·8	6 37·8	6 18·7	2·7	1·2	8·7	3·8	14·7	6·5
28	6 37·0	6 38·1	6 18·9	2·8	1·2	8·8	3·9	14·8	6·5
29	6 37·3	6 38·3	6 19·2	2·9	1·3	8·9	3·9	14·9	6·6
30	6 37·5	6 38·6	6 19·4	3·0	1·3	9·0	4·0	15·0	6·6
31	6 37·8	6 38·8	6 19·6	3·1	1·4	9·1	4·0	15·1	6·7
32	6 38·0	6 39·1	6 19·9	3·2	1·4	9·2	4·1	15·2	6·7
33	6 38·3	6 39·3	6 20·1	3·3	1·5	9·3	4·1	15·3	6·8
34	6 38·5	6 39·6	6 20·3	3·4	1·5	9·4	4·2	15·4	6·8
35	6 38·8	6 39·8	6 20·6	3·5	1·5	9·5	4·2	15·5	6·8
36	6 39·0	6 40·1	6 20·8	3·6	1·6	9·6	4·2	15·6	6·9
37	6 39·3	6 40·3	6 21·1	3·7	1·6	9·7	4·3	15·7	6·9
38	6 39·5	6 40·6	6 21·3	3·8	1·7	9·8	4·3	15·8	7·0
39	6 39·8	6 40·8	6 21·5	3·9	1·7	9·9	4·4	15·9	7·0
40	6 40·0	6 41·1	6 21·8	4·0	1·8	10·0	4·4	16·0	7·1
41	6 40·3	6 41·3	6 22·0	4·1	1·8	10·1	4·5	16·1	7·1
42	6 40·5	6 41·6	6 22·3	4·2	1·9	10·2	4·5	16·2	7·2
43	6 40·8	6 41·8	6 22·5	4·3	1·9	10·3	4·5	16·3	7·2
44	6 41·0	6 42·1	6 22·7	4·4	1·9	10·4	4·6	16·4	7·2
45	6 41·3	6 42·3	6 23·0	4·5	2·0	10·5	4·6	16·5	7·3
46	6 41·5	6 42·6	6 23·2	4·6	2·0	10·6	4·7	16·6	7·3
47	6 41·8	6 42·8	6 23·4	4·7	2·1	10·7	4·7	16·7	7·4
48	6 42·0	6 43·1	6 23·7	4·8	2·1	10·8	4·8	16·8	7·4
49	6 42·3	6 43·4	6 23·9	4·9	2·2	10·9	4·8	16·9	7·5
50	6 42·5	6 43·6	6 24·2	5·0	2·2	11·0	4·9	17·0	7·5
51	6 42·8	6 43·9	6 24·4	5·1	2·3	11·1	4·9	17·1	7·6
52	6 43·0	6 44·1	6 24·6	5·2	2·3	11·2	4·9	17·2	7·6
53	6 43·3	6 44·4	6 24·9	5·3	2·3	11·3	5·0	17·3	7·6
54	6 43·5	6 44·6	6 25·1	5·4	2·4	11·4	5·0	17·4	7·7
55	6 43·8	6 44·9	6 25·4	5·5	2·4	11·5	5·1	17·5	7·7
56	6 44·0	6 45·1	6 25·6	5·6	2·5	11·6	5·1	17·6	7·8
57	6 44·3	6 45·4	6 25·8	5·7	2·5	11·7	5·2	17·7	7·8
58	6 44·5	6 45·6	6 26·1	5·8	2·6	11·8	5·2	17·8	7·9
59	6 44·8	6 45·9	6 26·3	5·9	2·6	11·9	5·3	17·9	7·9
60	6 45·0	6 46·1	6 26·6	6·0	2·7	12·0	5·3	18·0	8·0

27ᵐ	SUN PLANETS	ARIES	MOON	v or d	Corrⁿ	v or d	Corrⁿ	v or d	Corrⁿ
s	° ′	° ′	° ′	′	′	′	′	′	′
00	6 45·0	6 46·1	6 26·6	0·0	0·0	6·0	2·8	12·0	5·5
01	6 45·3	6 46·4	6 26·8	0·1	0·0	6·1	2·8	12·1	5·5
02	6 45·5	6 46·6	6 27·0	0·2	0·1	6·2	2·8	12·2	5·6
03	6 45·8	6 46·9	6 27·3	0·3	0·1	6·3	2·9	12·3	5·6
04	6 46·0	6 47·1	6 27·5	0·4	0·2	6·4	2·9	12·4	5·7
05	6 46·3	6 47·4	6 27·7	0·5	0·2	6·5	3·0	12·5	5·7
06	6 46·5	6 47·6	6 28·0	0·6	0·3	6·6	3·0	12·6	5·8
07	6 46·8	6 47·9	6 28·2	0·7	0·3	6·7	3·1	12·7	5·8
08	6 47·0	6 48·1	6 28·5	0·8	0·4	6·8	3·1	12·8	5·9
09	6 47·3	6 48·4	6 28·7	0·9	0·4	6·9	3·2	12·9	5·9
10	6 47·5	6 48·6	6 28·9	1·0	0·5	7·0	3·2	13·0	6·0
11	6 47·8	6 48·9	6 29·2	1·1	0·5	7·1	3·3	13·1	6·0
12	6 48·0	6 49·1	6 29·4	1·2	0·6	7·2	3·3	13·2	6·1
13	6 48·3	6 49·4	6 29·7	1·3	0·6	7·3	3·3	13·3	6·1
14	6 48·5	6 49·6	6 29·9	1·4	0·6	7·4	3·4	13·4	6·1
15	6 48·8	6 49·9	6 30·1	1·5	0·7	7·5	3·4	13·5	6·2
16	6 49·0	6 50·1	6 30·4	1·6	0·7	7·6	3·5	13·6	6·2
17	6 49·3	6 50·4	6 30·6	1·7	0·8	7·7	3·5	13·7	6·3
18	6 49·5	6 50·6	6 30·8	1·8	0·8	7·8	3·6	13·8	6·3
19	6 49·8	6 50·9	6 31·1	1·9	0·9	7·9	3·6	13·9	6·4
20	6 50·0	6 51·1	6 31·3	2·0	0·9	8·0	3·7	14·0	6·4
21	6 50·3	6 51·4	6 31·6	2·1	1·0	8·1	3·7	14·1	6·5
22	6 50·5	6 51·6	6 31·8	2·2	1·0	8·2	3·8	14·2	6·5
23	6 50·8	6 51·9	6 32·0	2·3	1·1	8·3	3·8	14·3	6·6
24	6 51·0	6 52·1	6 32·3	2·4	1·1	8·4	3·9	14·4	6·6
25	6 51·3	6 52·4	6 32·5	2·5	1·1	8·5	3·9	14·5	6·6
26	6 51·5	6 52·6	6 32·8	2·6	1·2	8·6	3·9	14·6	6·7
27	6 51·8	6 52·9	6 33·0	2·7	1·2	8·7	4·0	14·7	6·7
28	6 52·0	6 53·1	6 33·2	2·8	1·3	8·8	4·0	14·8	6·8
29	6 52·3	6 53·4	6 33·5	2·9	1·3	8·9	4·1	14·9	6·8
30	6 52·5	6 53·6	6 33·7	3·0	1·4	9·0	4·1	15·0	6·9
31	6 52·8	6 53·9	6 33·9	3·1	1·4	9·1	4·2	15·1	6·9
32	6 53·0	6 54·1	6 34·2	3·2	1·5	9·2	4·2	15·2	7·0
33	6 53·3	6 54·4	6 34·4	3·3	1·5	9·3	4·3	15·3	7·0
34	6 53·5	6 54·6	6 34·7	3·4	1·6	9·4	4·3	15·4	7·1
35	6 53·8	54·9	6 34·9	3·5	1·6	9·5	4·4	15·5	7·1
36	6 54·0	55·1	6 35·1	3·6	1·7	9·6	4·4	15·6	7·2
37	6 54·3	6 55·4	6 35·4	3·7	1·7	9·7	4·4	15·7	7·2
38	6 54·5	6 55·6	6 35·6	3·8	1·7	9·8	4·5	15·8	7·2
39	6 54·8	6 55·9	6 35·9	3·9	1·8	9·9	4·5	15·9	7·3
40	6 55·0	6 56·1	6 36·1	4·0	1·8	10·0	4·6	16·0	7·3
41	6 55·3	6 56·4	6 36·3	4·1	1·9	10·1	4·6	16·1	7·4
42	6 55·5	6 56·6	6 36·6	4·2	1·9	10·2	4·7	16·2	7·4
43	6 55·8	6 56·9	6 36·8	4·3	2·0	10·3	4·7	16·3	7·5
44	6 56·0	6 57·1	6 37·0	4·4	2·0	10·4	4·8	16·4	7·5
45	6 56·3	6 57·4	6 37·3	4·5	2·1	10·5	4·8	16·5	7·6
46	6 56·5	6 57·6	6 37·5	4·6	2·1	10·6	4·9	16·6	7·6
47	6 56·8	6 57·9	6 37·8	4·7	2·2	10·7	4·9	16·7	7·7
48	6 57·0	6 58·1	6 38·0	4·8	2·2	10·8	5·0	16·8	7·7
49	6 57·3	6 58·4	6 38·2	4·9	2·2	10·9	5·0	16·9	7·7
50	6 57·5	6 58·6	6 38·5	5·0	2·3	11·0	5·0	17·0	7·8
51	6 57·8	6 58·9	6 38·7	5·1	2·3	11·1	5·1	17·1	7·8
52	6 58·0	6 59·1	6 39·0	5·2	2·4	11·2	5·1	17·2	7·9
53	6 58·3	6 59·4	6 39·2	5·3	2·4	11·3	5·2	17·3	7·9
54	6 58·5	6 59·6	6 39·4	5·4	2·5	11·4	5·2	17·4	8·0
55	6 58·8	6 59·9	6 39·7	5·5	2·5	11·5	5·3	17·5	8·0
56	6 59·0	7 00·1	6 39·9	5·6	2·6	11·6	5·3	17·6	8·1
57	6 59·3	7 00·4	6 40·2	5·7	2·6	11·7	5·4	17·7	8·1
58	6 59·5	7 00·6	6 40·4	5·8	2·7	11·8	5·4	17·8	8·2
59	6 59·8	7 00·9	6 40·6	5·9	2·7	11·9	5·5	17·9	8·2
60	7 00·0	7 01·1	6 40·9	6·0	2·8	12·0	5·5	18·0	8·3

Figure 8E.--An excerpt from "The Nautical Almanac"

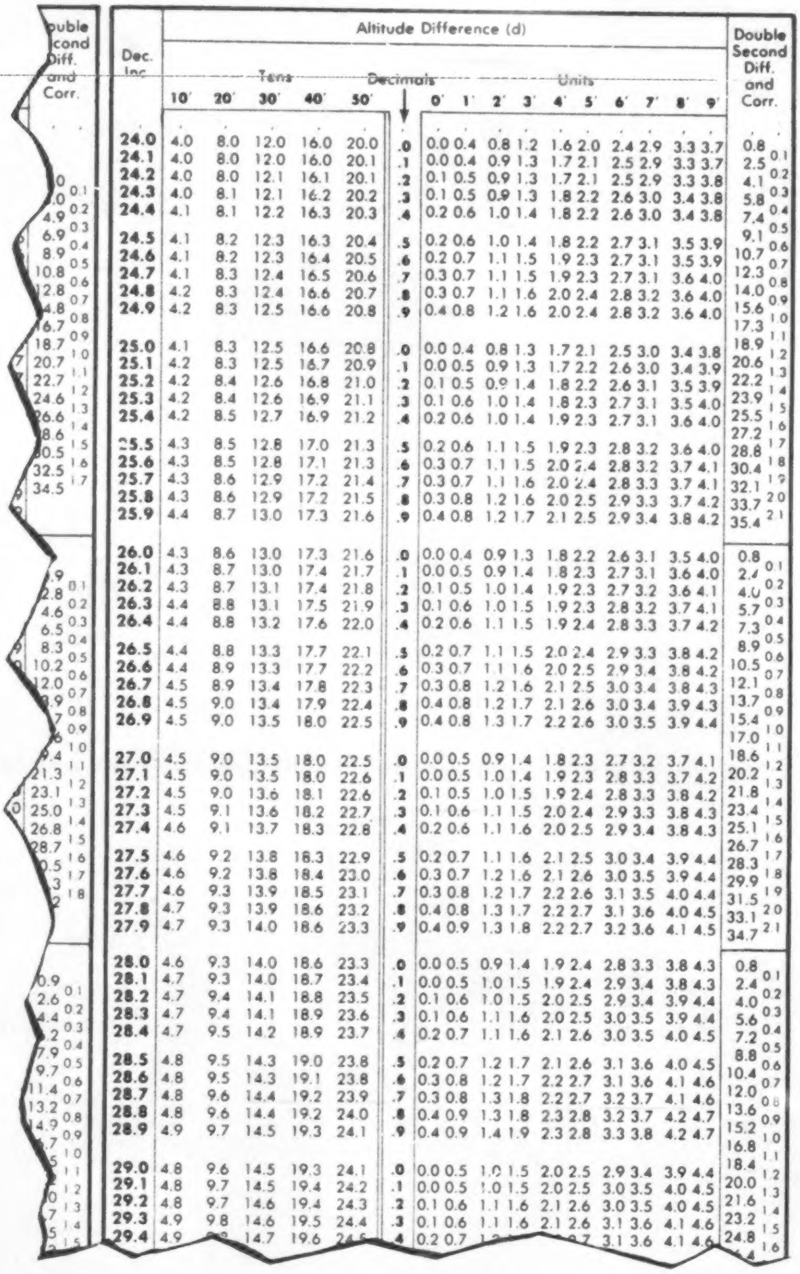


1°, 359° L.H.A. LATITUDE SAME NAME AS DECLINATION

Dec.	30°			31°			32°			33°			34°			35°		
	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z	Hc	d	Z
°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	°	° ′	′	
0	59 59.1	+ 60.0	178.0	58 59.1	+ 60.0	178.1	57 59.2	+ 59.9	178.1	56 59.2	+ 60.0	178.2	55 59.2	+ 60.0	178.2	54 59.3	+ 59.9	17
1	60 59.1	59.9	177.9	59 59.1	60.0	178.0	58 59.1	60.0	178.1	57 59.2	59.9	178.1	56 59.2	60.0	178.2	55 59.2	60.0	17
2	61 59.0	60.0	177.9	60 59.1	59.9	177.9	59 59.1	60.0	178.0	58 59.1	60.0	178.1	57 59.2	60.0	178.1	56 59.2	60.0	1
3	62 59.0	60.0	177.8	61 59.0	60.0	177.9	60 59.1	60.0	177.9	59 59.1	60.0	178.0	58 59.2	59.9	178.1	57 59.2	60.0	1
4	63 59.0	59.9	177.7	62 59.0	60.0	177.8	61 59.1	59.9	177.9	60 59.1	60.0	177.9	59 59.1	60.0	178.0	58 59.2	59.9	17
5	64 58.9	+ 60.0	177.6	63 59.0	+ 59.9	177.7	62 59.0	+ 60.0	177.8	61 59.1	+ 59.9	177.9	60 59.1	+ 60.0	177.9	59 59.1	+ 60.0	178.
6	65 58.9	59.9	177.6	64 58.9	60.0	177.6	63 59.0	60.0	177.7	62 59.0	60.0	177.8	61 59.1	60.0	177.9	60 59.1	60.0	177.9
7	66 58.8	60.0	177.5	65 58.9	60.0	177.6	64 59.0	59.9	177.7	63 59.0	60.0	177.7	62 59.1	59.9	177.8	61 59.1	60.0	177.9
8	67 58.8	60.0	177.4	66 58.9	59.9	177.5	65 58.9	60.0	177.6	64 59.0	59.9	177.7	63 59.0	60.0	177.7	62 59.1	59.9	177.8
9	68 58.8	59.9	177.2	67 58.8	60.0	177.4	66 58.9	59.9	177.5	65 58.9	60.0	177.6	64 59.0	59.9	177.7	63 59.0	60.0	177.
10	69 58.7	+ 59.9	177.1	68 58.8	+ 59.9	177.3	67 58.8	+ 60.0	177.4	66 58.9	+ 59.9	177.5	65 58.9	+ 60.0	177.6	64 59.0	+ 60.0	177
11	70 58.6	60.0	177.0	69 58.7	60.0	177.1	68 58.8	59.9	177.3	67 58.8	60.0	177.4	66 58.9	60.0	177.5	65 59.0	59.9	177
12	71 58.6	59.9	176.8	70 58.7	59.9	177.0	69 58.7	60.0	177.1	68 58.8	59.9	177.3	67 58.9	59.9	177.4	66 58.9	60.0	17
13	72 58.5	59.9	176.7	71 58.6	59.9	176.8	70 58.7	59.9	177.0	69 58.7	60.0	177.2	68 58.8	60.0	177.3	67 58.9	59.9	177
14	73 58.4	59.9	176.5	72 58.5	59.9	176.7	71 58.6	59.9	176.9	70 58.7	59.9	177.0	69 58.8	59.9	177.2	68 58.8	60.0	177
15	74 58.3	+ 59.9	176.3	73 58.4	+ 59.9	176.5	72 58.5	+ 60.0	176.7	71 58.6	+ 60.0	176.9	70 58.7	+ 60.0	177.0	69 58.8	+ 59.9	177.2
16	75 58.2	59.9	176.0	74 58.3	59.9	176.3	73 58.5	59.9	176.5	72 58.6	59.9	176.7	71 58.7	59.9	176.9	70 58.7	60.0	177.0
17	76 58.1	59.8	175.8	75 58.2	59.9	176.1	74 58.4	59.9	176.3	73 58.5	59.9	176.5	72 58.6	59.9	176.7	71 58.7	59.9	176.9
18	77 57.9	59.9	175.4	76 58.1	59.9	175.8	75 58.3	59.8	176.1	74 58.4	59.9	176.3	73 58.5	59.9	176.6	72 58.6	59.9	176.7
19	78 57.8	59.8	175.1	77 58.0	59.8	175.5	76 58.1	59.9	175.8	75 58.3	59.9	176.1	74 58.4	59.9	176.4	73 58.5	59.9	176.
20	79 57.6	+ 59.7	174.6	78 57.8	+ 59.8	175.1	77 58.0	+ 59.8	175.5	76 58.2	+ 59.8	175.8	75 58.3	+ 59.9	176.1	74 58.4	+ 59.9	17
21	80 57.3	59.7	174.1	79 57.6	59.7	174.6	78 57.8	59.8	175.1	77 58.0	59.9	175.5	76 58.2	59.9	175.9	75 58.3	59.9	17
22	81 57.0	59.6	173.4	80 57.3	59.7	174.1	79 57.6	59.8	174.7	78 57.9	59.8	175.2	77 58.1	59.8	175.5	76 58.2	59.9	17
23	82 56.6	− 59.5	172.5	81 57.0	59.6	173.4	80 57.4	59.7	174.1	79 57.7	59.7	174.7	78 57.9	59.8	175.2	77 58.1	59.8	175
24	83 56.1	59.2	171.3	82 56.6	59.5	172.5	81 57.1	59.6	173.5	80 57.4	59.7	174.2	79 57.7	59.8	174.8	78 57.9	59.9	175.
25	84 55.3	+ 58.9	169.7	83 56.1	+ 59.3	171.4	82 56.7	+ 59.5	172.6	81 57.1	+ 59.7	173.5	80 57.5	+ 59.7	174.2	79 57.8	+ 59.7	174.8
26	85 54.2	58.2	167.3	84 55.4	58.9	169.8	83 56.2	59.3	171.5	82 56.8	59.5	172.7	81 57.2	59.6	173.6	80 57.5	59.8	174.
27	86 52.4	56.6•	163.4	85 54.3	58.3	167.4	84 55.5	58.9	169.9	83 56.3	59.3	171.5	82 56.8	59.6	172.7	81 57.3	59.6	173
28	87 49.0	51.5•	156.1	86 52.6	56.6•	163.6	85 54.4	58.3	167.5	84 55.6	59.0	170.0	83 56.4	59.3	171.6	82 56.9	59.5	17
29	88 40.5	+ 27.5•	138.7	87 49.2	51.6•	156.3	86 52.7	56.7•	163.7	85 54.6	58.3	167.6	84 55.7	59.0	170.1	83 56.4	59.4	17
30	89 08.0	− 27.2•	89.7	88 40.8	+ 27.8•	139.0	87 49.4	+ 51.8•	156.5	86 52.9	+ 56.8•	163.9	85 54.7	+ 58.3	167.8	84 55.8	+ 59.0	1
31	88 40.8	51.4•	40.5	89 08.6	− 27.4•	89.7	88 41.2	+ 27.9•	139.3	87 49.7	51.8•	156.8	86 53.0	56.9•	164.0	85 54.8	58.4	16
32	87 49.4	56.5•	22.9	88 41.2	51.5•	40.2	89 09.1	− 27.6•	89.7	88 41.5	+ 28.2•	139.6	87 49.9	52.0•	157.0	86 53.2	56.9•	16
33	86 52.9	58.2	15.6	87 49.7	56.7•	22.7	88 41.5	51.6•	39.9	89 09.7	− 27.8•	89.7	88 41.9	+ 28.4•	139.9	87 50.1	52.2•	157.
34	85 54.7	58.9	11.7	86 53.0	58.2	15.4	87 49.9	56.7•	22.5	88 41.9	51.8•	39.5	89 10.3	− 28.0•	89.7	88 42.3	+ 28.6•	140.
35	84 55.8	− 59.3	9.3	85 54.8	− 58.9	11.6	86 53.2	− 58.3	15.3	87 50.1	− 56.8•	22.2	88 42.3	− 52.0•	39.2	89 10.9	− 28.3•	89.
36	83 56.5	59.5	7.7	84 55.9	59.3	9.2	85 54.9	58.9	11.4	86 53.3	58.3	15.1	87 50.3	56.8•	22.0	88 42.6	52.0•	38
37	82 57.0	59.6	6.5	83 56.6	59.5	7.6	84 56.0	59.3	9.1	85 55.0	58.9	11.3	86 53.5	58.4	14.9	87 50.6	56.9•	21
38	81 57.4	59.6	5.6	82 57.1	59.6	6.4	83 56.7	59.5	7.5	84 56.1	59.4	9.0	85 55.1	58.9	11.1	86 53.7	58.4	14
39	80 57.8	59.8	5.0	81 57.5	59.7	5.6	82 57.2	59.6	6.3	83 56.7	59.5	7.4	84 56.2	59.4	8.8	85 55.3	59.0	11.
40	79 58.0	− 59.8	4.4	80 57.8	− 59.7	4.9	81 57.6	− 59.7	5.5	82 57.2	− 59.6	6.3	83 56.8	− 59.5	7.3	84 56.3	− 59.4	8.
41	78 58.2	59.8	3.9	79 58.1	59.8	4.3	80 57.9	59.8	4.8	81 57.6	59.7	5.4	82 57.3	59.6	6.2	83 56.9	59.5	7.
42	77 58.4	59.9	3.6	78 58.3	59.9	3.9	79 58.1	59.8	4.3	80 57.9	59.7	4.7	81 57.7	59.7	5.3	82 57.4	59.6	6
43	76 58.5	59.8	3.2	77 58.4	59.8	3.5	78 58.3	59.8	3.8	79 58.2	59.9	4.2	80 58.0	59.8	4.7	81 57.8	59.8	
44	75 58.7	59.9	3.0	76 58.6	59.9	3.2	77 58.5	59.9	3.5	78 58.3	59.8	3.8	79 58.2	59.8	4.1	80 58.0	59.7	
45	74 58.8	− 59.9	2.7	75 58.7	− 59.9	2.9	76 58.6	− 59.9	3.1	77 58.5	− 59.9	3.4	78 58.4	− 59.8	3.7	79 58.3	− 59.9	
46	73 58.9	60.0	2.5	74 58.8	59.9	2.7	75 58.7	59.9	2.9	76 58.6	59.8	3.1	77 58.6	59.9	3.3	78 58.4	59.8	3
47	72 58.9	59.9	2.3	73 58.9	59.9	2.5	74 58.8	59.9	2.6	75 58.8	59.9	2.8	76 58.7	59.9	3.0	77 58.6	59.9	3
48	71 59.0	59.9	2.2	72 59.0	60.0	2.3	73 58.9	59.9	2.4	74 58.9	59.9	2.6	75 58.8	59.9	2.8	76 58.7	59.9	3
49	70 59.1	60.0	2.0	71 59.0	59.9	2.1	72 59.0	59.9	2.2	73 59.0	60.0	2.4	74 58.9	59.9	2.5	75 58.8	59.9	
50	69 59.1	− 59.9	1.9	70 59.1	− 59.9	2.0	71 59.1	− 60.0	2.1	72 59.0	− 59.9	2.2	73 59.0	− 59.9	2.3	74 58.9	− 59.9	
51	68 59.2	59.9	1.8	69 59.2	60.0	1.8	70 59.1	59.9	1.9	71 59.1	59.9	2.0	72 59.1	60.0	2.2	73 59.0	59.9	
52	67 59.3	60.0	1.6	68 59.2	59.9	1.7	69 59.2	59.9	1.8	70 59.2	60.0	1.9	71 59.1	59.9	2.0	72 59.1	59.9	
53	66 59.3	60.0	1.5	67 59.3	60.0	1.6	68 59.3	60.0	1.7	69 59.2	59.9	1.8	70 59.2	59.9	1.8	71 59.2	60.0	
54	65 59.3	59.9	1.4	66 59.3	59.9	1.5	67 59.3	60.0	1.6	68 59.3	60.0	1.6	69 59.3	60.0	1.7	70 59.2	59.9	
55	64 59.4	− 60.0	1.4	65 59.4	− 60.0	1.4	66 59.3	− 59.9	1.5	67 59.3	− 59.9	1.5	68 59.3	− 59.9	1.6	69 59.3	− 60.0	
56	63 59.4	59.9	1.3	64 59.4	60.0	1.3	65 59.4	60.0	1.4	66 59.4	60.0	1.4	67 59.4	60.0	1.5	68 59.3	59.9	1.
57	62 59.5	60.0	1.2	63 59.4	59.9	1.2	64 59.4	59.9	1.3	65 59.4	60.0	1.3	66 59.4	60.0	1.4	67 59.4	60.0	1.
58	61 59.5	60.0	1.1	62 59.5	60.0	1.2	63 59.5	60.0	1.2	64 59.4	59.9	1.3	65 59.4	59.9	1.3	66 59.4	59.9	1.
59	60 59.5	60.0	1.1	61 59.5	60.0	1.1	62 59.5	60.0	1.1	63 59.5	60.0	1.2	64 59.5	60.0	1.2	65 59.5	60.0	1
60	59 59.5	− 59.9	1.0	60 59.5	− 59.9	1.0	61 59.5	− 59.9	1.1	62 59.5	− 60.0	1.1	63 59.5	− 60.0	1.1	64 59.5	− 60.0	
61	58 59.6	60.0	0.9	59 59.6	60.0	1.0	60 59.6	60.0	1.0	61 59.5	59.9	1.0	62 59.5	59.9	1.1	63 59.5	59.9	
62	57 59.6	60.0	0.9	58 59.6	60.0	0.9	59 59.6	60.0	0.9	60 59.6	60.0	1.0	61 59.6	60.0	1.0	62 59.6	60.0	
63	56 59.6	60.0	0.8	57 59.6	60.0	0.9	58 59.6	60.0	0.9	59 59.6	60.0	0.9	60 59.6	60.0	0.9	61 59.6	60.0	
	55 59.6			56 59.6	59.9	0.8	57 59.6	59.9	0.8	58 59.6	60.0	0.9	59 59.6	60.0	0.9	60 59.6	60.0	0

N. Lat. { L.H.A. greater than 180°......Zn=Z
L.H.A. less than 180°............Zn=360°−Z

Figure 8F.--An excerpt from Pub No. 229



INTERPOLATION TABLE

Dec. Inc.	Altitude Difference (d)															
	Tens					Decimals	Units									
	10'	20'	30'	40'	50'	↓	0'	1'	2'	3'	4'	5'	6'	7'	8'	9'
24.0	4.0	8.0	12.0	16.0	20.0	.0	0.0	0.4	0.8	1.2	1.6	2.0	2.4	2.9	3.3	3.7
24.1	4.0	8.0	12.0	16.0	20.1	.1	0.0	0.4	0.9	1.3	1.7	2.1	2.5	2.9	3.3	3.7
24.2	4.0	8.0	12.1	16.1	20.1	.2	0.1	0.5	0.9	1.3	1.7	2.1	2.5	2.9	3.3	3.8
24.3	4.0	8.1	12.1	16.2	20.2	.3	0.1	0.5	0.9	1.3	1.8	2.2	2.6	3.0	3.4	3.8
24.4	4.1	8.1	12.2	16.3	20.3	.4	0.2	0.6	1.0	1.4	1.8	2.2	2.6	3.0	3.4	3.8
24.5	4.1	8.2	12.3	16.3	20.4	.5	0.2	0.6	1.0	1.4	1.8	2.2	2.7	3.1	3.5	3.9
24.6	4.1	8.2	12.3	16.4	20.5	.6	0.2	0.7	1.1	1.5	1.9	2.3	2.7	3.1	3.5	3.9
24.7	4.1	8.3	12.4	16.5	20.6	.7	0.3	0.7	1.1	1.5	1.9	2.3	2.7	3.1	3.6	4.0
24.8	4.2	8.3	12.4	16.6	20.7	.8	0.3	0.7	1.1	1.6	2.0	2.4	2.8	3.2	3.6	4.0
24.9	4.2	8.3	12.5	16.6	20.8	.9	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0
25.0	4.1	8.3	12.5	16.6	20.8	.0	0.0	0.4	0.8	1.3	1.7	2.1	2.5	3.0	3.4	3.8
25.1	4.2	8.3	12.5	16.7	20.9	.1	0.0	0.5	0.9	1.3	1.7	2.2	2.6	3.0	3.4	3.9
25.2	4.2	8.4	12.6	16.8	21.0	.2	0.1	0.5	0.9	1.4	1.8	2.2	2.6	3.1	3.5	3.9
25.3	4.2	8.4	12.6	16.9	21.1	.3	0.1	0.6	1.0	1.4	1.8	2.3	2.7	3.1	3.5	4.0
25.4	4.2	8.5	12.7	16.9	21.2	.4	0.2	0.6	1.0	1.4	1.9	2.3	2.7	3.1	3.6	4.0
25.5	4.3	8.5	12.8	17.0	21.3	.5	0.2	0.6	1.1	1.5	1.9	2.3	2.8	3.2	3.6	4.0
25.6	4.3	8.5	12.8	17.1	21.3	.6	0.3	0.7	1.1	1.5	2.0	2.4	2.8	3.2	3.7	4.1
25.7	4.3	8.6	12.9	17.2	21.4	.7	0.3	0.7	1.1	1.6	2.0	2.4	2.8	3.3	3.7	4.1
25.8	4.3	8.6	12.9	17.2	21.5	.8	0.3	0.8	1.2	1.6	2.0	2.5	2.9	3.3	3.7	4.2
25.9	4.4	8.7	13.0	17.3	21.6	.9	0.4	0.8	1.2	1.7	2.1	2.5	2.9	3.4	3.8	4.2
26.0	4.3	8.6	13.0	17.3	21.6	.0	0.0	0.4	0.9	1.3	1.8	2.2	2.6	3.1	3.5	4.0
26.1	4.3	8.7	13.0	17.4	21.7	.1	0.0	0.5	0.9	1.4	1.8	2.3	2.7	3.1	3.6	4.0
26.2	4.3	8.7	13.1	17.4	21.8	.2	0.1	0.5	1.0	1.4	1.9	2.3	2.7	3.2	3.6	4.1
26.3	4.4	8.8	13.1	17.5	21.9	.3	0.1	0.6	1.0	1.5	1.9	2.3	2.8	3.2	3.7	4.1
26.4	4.4	8.8	13.2	17.6	22.0	.4	0.2	0.6	1.1	1.5	1.9	2.4	2.8	3.3	3.7	4.2
26.5	4.4	8.8	13.3	17.7	22.1	.5	0.2	0.7	1.1	1.5	2.0	2.4	2.9	3.3	3.8	4.2
26.6	4.4	8.9	13.3	17.7	22.2	.6	0.3	0.7	1.1	1.6	2.0	2.5	2.9	3.4	3.8	4.2
26.7	4.5	8.9	13.4	17.8	22.3	.7	0.3	0.8	1.2	1.6	2.1	2.5	3.0	3.4	3.8	4.3
26.8	4.5	9.0	13.4	17.9	22.4	.8	0.4	0.8	1.2	1.7	2.1	2.6	3.0	3.4	3.9	4.3
26.9	4.5	9.0	13.5	18.0	22.5	.9	0.4	0.8	1.3	1.7	2.2	2.6	3.0	3.5	3.9	4.4
27.0	4.5	9.0	13.5	18.0	22.5	.0	0.0	0.5	0.9	1.4	1.8	2.3	2.7	3.2	3.7	4.1
27.1	4.5	9.0	13.5	18.0	22.6	.1	0.0	0.5	1.0	1.4	1.9	2.3	2.8	3.3	3.7	4.2
27.2	4.5	9.0	13.6	18.1	22.6	.2	0.1	0.5	1.0	1.5	1.9	2.4	2.8	3.3	3.8	4.2
27.3	4.5	9.1	13.6	18.2	22.7	.3	0.1	0.6	1.1	1.5	2.0	2.4	2.9	3.3	3.8	4.3
27.4	4.6	9.1	13.7	18.3	22.8	.4	0.2	0.6	1.1	1.6	2.0	2.5	2.9	3.4	3.8	4.3
27.5	4.6	9.2	13.8	18.3	22.9	.5	0.2	0.7	1.1	1.6	2.1	2.5	3.0	3.4	3.9	4.4
27.6	4.6	9.2	13.8	18.4	23.0	.6	0.3	0.7	1.2	1.6	2.1	2.6	3.0	3.5	3.9	4.4
27.7	4.6	9.3	13.9	18.5	23.1	.7	0.3	0.8	1.2	1.7	2.2	2.6	3.1	3.5	4.0	4.4
27.8	4.7	9.3	13.9	18.6	23.2	.8	0.4	0.8	1.3	1.7	2.2	2.7	3.1	3.6	4.0	4.5
27.9	4.7	9.3	14.0	18.6	23.3	.9	0.4	0.9	1.3	1.8	2.2	2.7	3.2	3.6	4.1	4.5
28.0	4.6	9.3	14.0	18.6	23.3	.0	0.0	0.5	0.9	1.4	1.9	2.4	2.8	3.3	3.8	4.3
28.1	4.7	9.3	14.0	18.7	23.4	.1	0.0	0.5	1.0	1.5	1.9	2.4	2.9	3.4	3.8	4.3
28.2	4.7	9.4	14.1	18.8	23.5	.2	0.1	0.6	1.0	1.5	2.0	2.5	2.9	3.4	3.9	4.4
28.3	4.7	9.4	14.1	18.9	23.6	.3	0.1	0.6	1.1	1.6	2.0	2.5	3.0	3.5	3.9	4.4
28.4	4.7	9.5	14.2	18.9	23.7	.4	0.2	0.7	1.1	1.6	2.1	2.6	3.0	3.5	4.0	4.5
28.5	4.8	9.5	14.3	19.0	23.8	.5	0.2	0.7	1.2	1.7	2.1	2.6	3.1	3.6	4.0	4.5
28.6	4.8	9.5	14.3	19.1	23.8	.6	0.3	0.8	1.2	1.7	2.2	2.7	3.1	3.6	4.1	4.6
28.7	4.8	9.6	14.4	19.2	23.9	.7	0.3	0.8	1.3	1.8	2.2	2.7	3.2	3.7	4.1	4.6
28.8	4.8	9.6	14.4	19.2	24.0	.8	0.4	0.9	1.3	1.8	2.3	2.8	3.2	3.7	4.2	4.7
28.9	4.9	9.7	14.5	19.3	24.1	.9	0.4	0.9	1.4	1.9	2.3	2.8	3.3	3.8	4.2	4.7
29.0	4.8	9.6	14.5	19.3	24.1	.0	0.0	0.5	1.0	1.5	2.0	2.5	2.9	3.4	3.9	4.4
29.1	4.8	9.7	14.5	19.4	24.2	.1	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
29.2	4.8	9.7	14.6	19.4	24.3	.2	0.1	0.6	1.1	1.6	2.1	2.6	3.0	3.5	4.0	4.5
29.3	4.9	9.8	14.6	19.5	24.4	.3	0.1	0.6	1.1	1.6	2.1	2.6	3.1	3.6	4.1	4.6
29.4	4.9	[illegible]	14.7	19.6	[illegible]	.4	0.2	0.7	[illegible]	[illegible]	[illegible]	[illegible]	3.1	3.6	4.1	4.6

Double Second Diff. and Corr. (24.0–25.9)	
0.8	
	0.1
2.5	
	0.2
4.1	
	0.3
5.8	
	0.4
7.4	
	0.5
9.1	
	0.6
10.7	
	0.7
12.3	
	0.8
14.0	
	0.9
15.6	
	1.0
17.3	
	1.1
18.9	
	1.2
20.6	
	1.3
22.2	
	1.4
23.9	
	1.5
25.5	
	1.6
27.2	
	1.7
28.8	
	1.8
30.4	
	1.9
32.1	
	2.0
33.7	
	2.1
35.4	

Double Second Diff. and Corr. (26.0–27.9)	
0.8	
	0.1
2.4	
	0.2
4.0	
	0.3
5.7	
	0.4
7.3	
	0.5
8.9	
	0.6
10.5	
	0.7
12.1	
	0.8
13.7	
	0.9
15.4	
	1.0
17.0	
	1.1
18.6	
	1.2
20.2	
	1.3
21.8	
	1.4
23.4	
	1.5
25.1	
	1.6
26.7	
	1.7
28.3	
	1.8
29.9	
	1.9
31.5	
	2.0
33.1	
	2.1
34.7	

Double Second Diff. and Corr. (28.0–29.4)	
0.8	
	0.1
2.4	
	0.2
4.0	
	0.3
5.6	
	0.4
7.2	
	0.5
8.8	
	0.6
10.4	
	0.7
12.0	
	0.8
13.6	
	0.9
15.2	
	1.0
16.8	
	1.1
18.4	
	1.2
20.0	
	1.3
21.6	
	1.4
23.2	
	1.5
24.8	
	1.6

Figure 8F.--An excerpt from Pub No. 229

● Information for items 8-33 thru 8-44. During morning twilight on 2 September 1975, the DR position of your ship is latitude 33°49.0'N, longitude 145°03.0'W. At zone time $05^h26^m21^s$ the navigator observes the star Aldebaran with a sextant, having an IC of (-)1.0, from a height of 53 feet. The HS is 72°48.9'.

8-33. What is the total correction to be applied to the sextant altitude?
1. (-)1.0
2. (-)7.4
3. (-)8.4
4. (-)9.0

8-34. What is the observed altitude (Ho)?
1. 72°40.5'
2. 72°58.9'
3. 73°07.3'
4. 73°28.5'

8-35. What is the declination of the star?
1. 16°27.7'N
2. 16°27.7'S
3. 291°30.2'W
4. 291°30.2'E

8-36. What is the Greenwich mean time (GMT) of the sight?
1. $19^h26^m21^s$ 1 September
2. $05^h26^m21^s$ 2 September
3. $15^h26^m21^s$ 2 September
4. $16^h26^m21^s$ 2 September

8-37. What is the GHA of Aries for the time of observation?
1. 55°53.9'
2. 206°08.4'
3. 212°54.9'
4. 265°29.3'

8-38. What is the SHA of the star?
1. 144°25.1'
2. 206°18.6'
3. 265°29.3'
4. 291°21.9'

8-39. What is the GHA of the star?
1. 291°30.2'
2. 212°54.9'
3. 206°18.6'
4. 144°06.6'

8-40. What is the LHA of the star?
1. 359°
2. 181°
3. 179°
4. 269°

● Use latitude 34°N for AP.

8-41. What is the computed altitude (Hc) of the star?
1. 72°28.6'
2. 72°26.3'
3. 72°58.9'
4. 72°50.5'

8-42. What is the computed azimuth angle (Z) of the star?
1. S 003.2°E
2. N 176.9°E
3. N 183.2°W
4. S 356.8°W

8-43. What is the true azimuth (Zn) of the star?
1. 356.8°
2. 183.2°
3. 176.9°
4. 003.4°

8-44. What is the altitude intercept (a) and in which direction from the GP is it drawn?
1. 14.5 miles toward
2. 14.5 miles away
3. 3.3 miles toward
4. 3.3 miles away

8-45. What values must be known to use Pub No. 249 in finding the computed altitude and azimuth of a celestial body?
1. Latitude, declination, and meridian angle
2. Latitude, longitude, and GHA of the body
3. Latitude of LHAT of the body
4. Latitude, longitude, declination, GHA, and LHA of the body

8-46. Which of the following describes local apparent noon (LAN)?
1. The approximate instant the Sun passes over the observer's meridian
2. The exact instant the Sun passes over the observer's meridian
3. The method by which a ship's longitude is determined at 1200
4. The method by which 1200 local mean time is determined

Learning Objective: Define tidal terms.

8-47. The period during high and low water when the water level remains steady is called
   1. range
   2. stand
   3. mean sea level
   4. reference plane

8-48. The total rise from low water to high water is called the tide's
   1. rip
   2. range
   3. stand
   4. spring

8-49. What is the plane midway between mean high and mean low water called?
   1. Mean sea level
   2. Mean stand
   3. Mean tide level
   4. All the above

8-50. What type of tide is produced when the Moon is in its first and last quarters?
   1. Spring
   2. Solar
   3. Neap
   4. Rip

8-51. What does a depth of water figure on a chart indicate?
   1. The average depth soundings taken at various high water times
   2. The average depth soundings taken at various low water times
   3. The greatest depth sounding ever recorded at low water
   4. The greatest depth sounding ever recorded at high water

- Refer to table 13-1 of your text in answering items 8-52 thru 8-54.

8-52. Which of the following 1975 date-time readings for The Battery, New York, represents a lower low water?
   1. 11 July 0349
   2. 4 August 1127
   3. 18 August 1146
   4. 3 September 1203

8-53. Approximately how many hours elapse between successive high tides?
   1. 6 hours
   2. 12 hours
   3. 18 hours
   4. 24 hours

8-54. On which of the following dates was (A) only one low tide recorded at The Battery, New York, and (B) what was responsible for this phenomenon?
   1. (A) 20 July, (B) the preceding low tide occurred shortly before midnight
   2. (A) 20 July, (B) the preceding high tide occurred shortly before midnight
   3. (A) 1 September, (B) the preceding low tide occurred shortly before midnight
   4. (A) 1 September, (B) the preceding high tide occurred shortly before midnight

8-55. Tidal data for a subordinate station are obtained by applying a height difference or a ration of ranges to the predictions for the
   1. general area
   2. stated reference station
   3. nearest secondary station
   4. closest main subordinate station

- Refer to table 13-1 in your text to answer items 8-56 thru 8-60.

8-56. At what time on 11 August 1975 did (A) high tide occur at New York, Chelsea Docks, and (B) what was the height in feet?
   1. (A) 0056, (B) 4.6
   2. (A) 0001, (B) 4.9
   3. (A) 1141, (B) 5.4
   4. (A) 1237, (B) 5.2

8-57. What was the duration of fall of tide from first high to first low at Bayonne, New Jersey, on 10 Sept 1975?
   1. 6 hours 5 minutes
   2. 6 hours 22 minutes
   3. 12 hours 24 minutes
   4. 12 hours 45 minutes

8-58. What was the time of morning high tide at Bay Ridge, New York, on 3 September 1975?
1. 0617
2. 0613
3. 0525
4. 0453

8-59. Assume that your ship is entering the area adjacent to Union Stock Yards, New York, at 0900 (DST) 11 August 1975. What is the height of the tide?
1. 0.6 foot
2. 1.0 foot
3. 1.3 feet
4. 1.5 feet

8-60. What was the maximum difference between low and high tides at Dobbs Ferry on 19 July 1975?
1. 2.1
2. 3.4
3. 4.0
4. 5.3

8-61. The figures in the column at the left in the upper part of Tide Table 3 represent
1. time differences between low and high tides
2. time differences between successive low or successive high tides
3. times of high tide
4. times of low tide

Learning Objective: Describe tidal currents.

8-62. What term refers to the horizontal motion of water away from land caused by a falling tide?
1. Run
2. Ebb
3. Flood
4. Drift

8-63. The period of time during which tidal currents reverse their direction is referred to as
1. ebb current
2. slack water
3. flood current
4. drift water

8-64. What term refers to the direction of a tidal current?
1. Drift
2. Run
3. Set
4. Flood

8-65. Which agency publishes Tidal Current Tables?
1. United States Naval Institute
2. Hydrographic Office
3. Naval Observatory
4. National Ocean Survey

Learning Objective: Determine tidal current speeds and directions.

8-66. What is the direction and average velocity of the ebb current at Riverdale?
1. 15°, 1.4 knots
2. 15°, 2.0 knots
3. 200°, 1.4 knots
4. 200°, 2.0 knots

8-67. A fix has located your anchored ship at L40°30'N, λ73°58'W at 1500 on 15 September 1975. What time does the next slack water period occur at this position?
1. 1530
2. 1612
3. 1701
4. 1811

8-68. What was the current velocity at Rockaway Inlet at 2115 on 20 October 1975?
1. 1.3E
2. 1.3F
3. 2.6E
4. 2.6F

8-69. Assume you are at Riverdale at 1430 on 10 September 1975. What is the nearest time of maximum current?
1. 1224
2. 1228
3. 1847
4. 1849

8-70. If no other information is given in the current tables, you may assume that the set of the ebb current is approximately equal to the

1. flood velocity
2. spring velocity
3. flood direction
4. reciprocal of the flood direction

8-71. The height of tide at a given point will be lower than the predicted value if the barometer is ___A___ or the wind blows
low, high
___B___
offshore, onshore

1. A - low, B - offshore
2. A - low, B - onshore
3. A - high, B - offshore
4. A - high, B - onshore

Assignment 9

Tides and Currents (continued); and Weather

Textbook; NAVEDTRA 10149-F: Pages 208-237

Learning Objective: See appropriate publications to compute sunrise, sunset, moonrise, and moonset.

9-1. If sunrise in 40°N latitude is at 0615, at what time does twilight begin?
1. 0545
2. 0615
3. 0645
4. 0700

9-2. What is the period of time between sunrise predictions published in (A) the Tide Tables, and (B) the Nautical Almanac?
1. Both (A) and (B) every fifth day
2. (A) Every third day, (B) every fifth day
3. Both (A) and (B) every third day
4. (A) Every fifth day, (B) every third day

9-3. What was the time of sunrise at 35°N latitude on 3 May 1975 according to table 13-7 in your textbook?
1. 0503 LMT
2. 0506 LMT
3. 0508 LMT
4. 0511 LMT

- For items 9-4 thru 9-7 use table 9A.

9-4. Assume that your ship observes sunrise at 0505 on 4 August 1975 at latitude 38°N, longitude 75°W. From your position what was the time of sunrise on 4 August at latitude 38°N, longitude 22°31'W?
1. 0005 hours
2. 0135 hours
3. 0505 hours
4. 0735 hours

9-5. What was the time of sunset 7°20' east of Hampton Roads on 7 August 1975?
1. 1837 hours
2. 1850 hours
3. 1902 hours
4. 1940 hours

9-6. Refer to table 13-8 in your textbook. Assume your position is exactly 75°W longitude and sunset is calculated to occur at 1730. What is (A) the date and (B) your latitude?
1. (A) 24 June 1975, (B) 48°S
2. (A) 25 June 1975, (B) 48°S
3. (A) 25 June 1975, (B) 20°S
4. (A) 26 June 1975, (B) 20°N

9-7. What was the time (LMT) of sunrise at Hampton Roads on 26 June 1975?
1. 0432 hours
2. 0441 hours
3. 0446 hours
4. 0453 hours

Table 9A is the table used to apply a correction for longitude when predicting sunrise and sunset by tide tables. Table 9A is the table 5 of the Tide Tables referred to in your textbook.

The following information describes how to use table 9A.

If local meridian is east of standard meridian, subtract the correction from local time.

If local meridian is west of standard meridian, add the correction to local time.

For differences of longitude less than 15°, use the first part of the table. For greater differences use both parts thus: 47°23' is equivalent to 45° +2°23', the correction for 45° is 3 hours, the correction for 2°23' is 10 minutes, therefore, the total correction for the difference in longitude 47°23' is 3 hours and 10 minutes.

Difference of longitude between local and standard meridian	Correction to local civil time to obtain standard time	Difference of longitude between local and standard meridian	Correction to local civil time to obtain standard time	Difference of longitude between local and standard meridian	Correction to local civil time to obtain standard time
° ′ ° ′	*Minutes*	° ′ ° ′	*Minutes*	°	*Hours*
0 00 to 0 07	0	7 23 to 7 37	30	15	1
0 08 to 0 22	1	7 38 to 7 52	31	30	2
0 23 to 0 37	2	7 53 to 8 07	32	45	3
0 38 to 0 52	3	8 08 to 8 22	33	60	4
0 53 to 1 07	4	8 23 to 8 37	34	75	5
1 08 to 1 22	5	8 38 to 8 52	35	90	6
1 23 to 1 37	6	8 53 to 9 07	36	105	7
1 38 to 1 52	7	9 08 to 9 22	37	120	8
1 53 to 2 07	8	9 23 to 9 37	38	135	9
2 08 to 2 22	9	9 38 to 9 52	39	150	10
2 23 to 2 37	10	9 53 to 10 07	40	165	11
2 38 to 2 52	11	10 08 to 10 22	41	180	12
2 53 to 3 07	12	10 23 to 10 37	42		
3 08 to 3 22	13	10 38 to 10 52	43		
3 23 to 3 37	14	10 53 to 11 07	44		
3 38 to 3 52	15	11 08 to 11 22	45		
3 53 to 4 07	16	11 23 to 11 37	46		
4 08 to 4 22	17	11 38 to 11 52	47		
4 23 to 4 37	18	11 53 to 12 07	48		
4 38 to 4 52	19	12 08 to 12 22	49		
4 53 to 5 07	20	12 23 to 12 37	50		
5 08 to 5 22	21	12 38 to 12 52	51		
5 23 to 5 37	22	12 53 to 13 07	52		
5 38 to 5 52	23	13 08 to 13 22	53		
5 53 to 6 07	24	13 23 to 13 37	54		
6 08 to 6 22	25	13 38 to 13 52	55		
6 23 to 6 37	26	13 53 to 14 07	56		
6 38 to 6 52	27	14 08 to 14 22	57		
6 53 to 7 07	28	14 23 to 14 37	58		
7 08 to 7 22	29	14 38 to 14 52	59		

Table 9A.--Reduction of Local Mean Time to Standard Time.

9-8. At what standard time did the sun rise on 25 June 1975 at a position that is exactly 16°N of Hampton Roads?
1. 0115 hours
2. 0248 hours
3. 0340 hours
4. 0346 hours

9-9. What time (LMT) did the Moon set on 26 June 1975 at 50°S latitude and 36°E longitude?
1. 0848
2. 0918
3. 1051
4. 1112

Learning Objective: Identify major components of the atmosphere and their general effect on weather.

9-10. What gas, near the Earth's surface, has the largest percentage by volume of the atmosphere?
1. Oxygen
2. Argon
3. Nitrogen
4. Helium

9-11. Which of the following is a factor in considering the makeup of weather?
1. Humidity
2. Atmospheric pressure
3. Temperature
4. All the above

Learning Objective: Determine atmospheric temperatures, dewpoint, and humidity.

9-12. A temperature of 72°F is equivalent to what Celsius temperature?
1. 22.2°
2. 57.7°
3. 161.6
4. 62.3

9-13. A temperature of 54.8C is equivalent to what Fahrenheit temperature?
1. 128.6°
2. 130.6°
3. 132.6
4. 134.6

9-14. What instrument is used to determine relative humidity and dewpoint?
1. Anemometer
2. Synchro repeater
3. Psychrometer
4. Aneroid barometer

9-15. The difference between the wet-bulb and the dry-bulb thermometer readings is used to determine the
1. diurnal variation
2. relative humidity
3. minimum temperature
4. maximum temperature

9-16. What is the relative humidity when the amount of water vapor in the air has reached the saturation point?
1. 0 percent
2. 50 percent
3. 100 percent
4. Impossible to determine without knowing the air temperature

9-17. The difference between the dry-bulb and wet-bulb readings is called "the depression of the wet-bulb."

9-18. What is the dewpoint if the air temperature is 50°F and the relative humidity is 100 percent?
1. 50°F
2. 60°F
3. 80°F
4. 100°F

9-19. What is the dewpoint if the wet-bulb temperature is 58°F and the dry-bulb temperature is 65°F?
1. 47°F
2. 53°F
3. 58°F
4. 65°F

Learning Objective: Identify the different types of barometers.

9-20. The primary purpose of a barometer is to measure the
1. altitude above or below sea level
2. variations in ambient temperature
3. amount of relative humidity
4. variations in atmospheric pressure

9-21. What are the two types of barometers used by the Navy?
1. Aneroid and isometric
2. Mercurial and alcohol
3. Mercurial and aneroid
4. Isometric and metallic

9-22. For which of the following must an aneroid barometer be corrected?
1. Humidity
2. Temperature
3. Latitude
4. Altitude

9-23. Barometers are graduated in either inches of mercury or millimeters.

9-24. What is the average atmospheric pressure at the Earth's surface?
1. 28.92 inches
2. 29.50 inches
3. 29.92 inches
4. 30.32 inches

Learning Objective: Identify atmospheric conditions and characteristics.

9-25. A boundary between distinctively different air masses is called
1. a pressure area
2. maritime masses
3. a front
4. all the above

9-26. In what values are pressure points usually indicated in weather charts?
1. Isobars
2. Centimeters
3. Inches
4. Millibars

9-27. Isobars are lines on a weather chart that connect points of equal
1. temperature
2. humidity
3. pressure
4. wind velocity

9-28. Which of the following atmospheric features is determined by the amount of difference in pressure, and the distance of the high pressure area from the low pressure area?
1. Size of the pressure area
2. Cloud heights
3. Wind strength
4. All the above

9-29. The wind velocity is likely to be highest in the area on a weather chart where the isobars are
1. widely separated
2. close together
3. V-shaped
4. curved

9-30. Which of the following alternatives defines a cyclone?
1. An approximately circular portion of the atmosphere, in the vicinity of an atmospheric high
2. The thin zone of discontinuity between two air masses
3. An approximately circular portion of the atmosphere, in the vicinity of an atmospheric low
4. A movement of air down a pressure gradient from higher to lower pressure

---

Learning Objective: Determine wind flows in different pressure areas.

- Items 9-31 and 9-32 refer to figure 14-12 in your text.

9-31. In what direction does the air move in a cyclone that is centered over the state of Kansas?
1. Counterclockwise toward the center
2. Clockwise toward the center
3. Counterclockwise away from the center
4. Clockwise away from the center

9-32. Assume you are in the Southern Hemisphere facing the wind that is circulating around a low pressure area. Where is the center of the area in relation to your position?
1. Toward your left
2. Directly in front of you
3. Directly in back of you
4. Toward your right

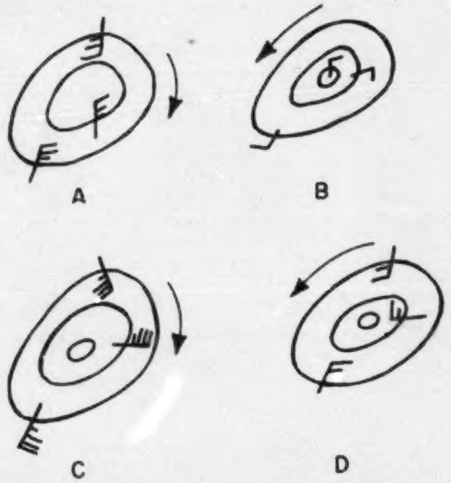


Figure 9A.--Wind flow around pressure area

9-33. Which pressure area in figure 9A represents a Southern Hemisphere anticyclone with wind velocities of 15 knots?
1. A
2. B
3. C
4. D

9-34. Which pressure area in figure 9A represents a Northern Hemisphere cyclone with wind velocities of 10 knots?
1. A
2. B
3. C
4. D

9-35. A tropical cyclone in the West Indies is usually called a
1. typhoon
2. hurricane
3. doldrum
4. tornado

9-36. Which of the following is characteristic of the center of a tropical cyclone?
1. A low, dense cloud cover
2. A calm sea
3. Calm or light air
4. Extremely high winds

9-37. Which of the following regions is normally free of tropical cyclones?
1. North Atlantic
2. South Atlantic
3. North Pacific
4. South Pacific

Learning Objective: Record and interpret synoptic observations.

9-38. In what publications will you find details for recording weather observations and for coding these observations for radio transmission?
1. Deck log
2. Navigator's notebook
3. Fleet Weather Central Log
4. Manual for Surface Weather Observation

9-39. What plain language word is inserted before the 5-digit coded weather message to explain a certain weather phenomenon?
1. Rain
2. Hail
3. Ice
4. Thunderstorms

9-40. What two elements of weather can best be used to assist you in forecasting bad weather?
1. Temperature and atmospheric pressure
2. Cloud formations and wind
3. Wind and atmospheric pressure
4. Temperature and cloud formations

9-41. The twice daily variation in the barometer is called
1. barometer correction
2. diurnal change
3. pressure front
4. frontal masses

9-42. Assume that the graph shown in textbook figure 14-16 represents readings taken at Norfolk, Virginia on 25 January 1976 and that the 1000 reading is the lowest recorded for that hour during the period 1 - 25 January 1976. The readings taken at 1000 on 26 January 1976 and at 1000 on 27 January 1976 were 29.86 and 29.83 respectively. (A) What does this situation indicate, and (B) what action, if any, should you take?
1. (A) A high-pressure area is approaching; (B) the OOD should be notified
2. (A) A low-pressure area is approaching; (B) the OOD should be notified
3. (A) A low-pressure area is approaching; (B) none, this is a normal diurnal change
4. (A) A high-pressure area is approaching; (B) none, this is a normal diurnal change

---

Learning Objective: Determine wind by the Beaufort scale.

9-43. When the Beaufort scale is used, the wind velocity is estimated by observing the
1. effect of the wind on the surface of the sea
2. speed of the lowest clouds in the sky
3. trend of the pressure and air temperature
4. rate of evaporation from a water surface

9-44. A wind of Beaufort force 5 is called a
1. moderate breeze
2. moderate gale
3. fresh breeze
4. fresh gale

Learning Objective: Identify methods of determining wind speed and direction.

9-45. An instrument used to measure wind speed on a ship is called a
1. thermograph
2. theodolite
3. clinometer
4. anemometer

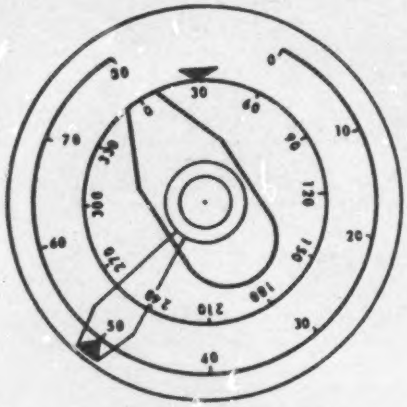


Figure 9B.--Anemometer repeater

● In answering items 9-46 thru 9-50, assume that the anemometer synchro repeater shown in figure 9B is on the bridge of a ship making 30 knots on course 270°T.

9-46. The dial of the anemometer synchro repeater in figure 9B indicates a relative wind direction of
1. 000°
2. 030°
3. 080°
4. 250°

9-47. The outer scale of the anemometer synchro repeater in figure 9B indicates the
1. ship's heading
2. ship's speed
3. relative wind direction
4. relative wind velocity

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9-48. What is the velocity of the ship's wind in the situation in figure 9B?
   1. 20 knots
   2. 30 knots
   3. 50 knots
   4. 80 knots

9-49. The direction of the ship's wind in the situation in figure 9B is from
   1. 000°T
   2. 090°T
   3. 180°T
   4. 270°T

9-50. The direction of the resultant wind in the situation in figure 9B is from
   1. 060°T
   2. 120°T
   3. 240°T
   4. 300°T

Learning Objective: Identify the types of clouds and fogs and describe related weather.

9-51. By what basic process does water vapor form clouds?
   1. Crystallization
   2. Distillation
   3. Evaporation
   4. Condensation

9-52. Which of the following is not necessary for clouds to form?
   1. Wind
   2. Moisture
   3. A cooling process
   4. Nygroscopic nuclei

9-53. Clouds described as hook-shaped, thin, and feather-like are identified by the name
   1. cirrus
   2. stratus
   3. cumulus
   4. nimbostratus

9-54. What type of clouds are associated with the term mackerel sky?
   1. Cirrostratus
   2. Cumulonimbus
   3. Stratocumulus
   4. Cirrocumulus

9-55. What type of weather usually follows cirrostratus clouds that were preceded by some other form of cirrus clouds?
   1. Fog
   2. Fair
   3. Clear and cold
   4. Rain

In items 9-56 thru 9-58, select the classes of clouds from column B that are contained in the family of clouds listed in column A. Refer to figure 14-29 of your text.

A. Family	B. Classes
9-56. High clouds	1. Altocumulus
9-57. Middle clouds	2. Cirrocumulus
9-58. Low clouds	3. Cumulus
	4. Stratocumulus

9-59. Continuous rain may be expected from what type of cloud?
   1. Stratus
   2. Altostratus
   3. Stratocumulus
   4. Nimbostratus

9-60. Vertical development is indicative of which cloud types?
   1. Altostratus and cumulus
   2. Cumulonimbus and stratus
   3. Stratus and nimbostratus
   4. Cumulus and cumulonimbus

9-61. A distinctive feature of cumulonimbus clouds is their
   1. hazy appearance
   2. wispiness
   3. anvil-shaped tops
   4. shapelessness

9-62. Which form of precipitation might you expect from cumulonimbus clouds?
   1. Rain
   2. Snow
   3. Hail
   4. Any of the above

9-63. Which of the following conditions will probably cause onshore winds to produce fog along a coastline?
   1. The onshore winds are forced upward by the land
   2. The waters adjacent to the land are colder than the waters farther offshore
   3. The Sun heats the land for a considerable distance inland
   4. The water heats up and cools faster than the land

Learning Objective: Recognize characteristics of weather fronts.

9-64. The area of convergence of warm and cold fronts usually is a low-pressure area.

9-65. The passage of which type of weather front is usually accompanied by a relatively narrow but often violent band of weather?
1. Warm front
2. An occluded front
3. Slow-moving cold front
4. Fast-moving cold front

9-66. A steady drizzle is falling during the approach of a warm front. What type of cloud first precedes the front?
1. Cirrostratus
2. Cirrus
3. Altostratus
4. Cumulonimbus

Learning Objective: Interpret storm-warning signals.

In items 9-67 thru 9-72, select from column B the wind speeds indicated by the storm-warning signals in column A.

A. Signals

9-67. Two square red flags with black centers by day

9-68. A white light above a red light at night

9-69. A white light between two red lights at night

9-70. One red pennant by day

9-71. One red flag with a black center by day

9-72. Two red pennants by day

B. Wind Speeds

1. Up to 33 knots
2. From 34 to 48 knots
3. From 48 to 63 knots
4. From 64 knots and above

Assignment 10

Maneuvering Board; Communications

Textbook, NAVEDTRA 10149-F: Pages 238-267

Learning Objective: Describe relative motion and the relative plot.

● Prior to commencing the maneuvering board section (items 10-10 through 10-33) you should have available; soft lead pencil, dividers, and parallel rulers. Several blank maneuvering boards are provided with the course.

10-1. In which of the following situations is there no relative movement between two ships?

1. One ship is stationary and the other has way on
2. Both ships are steaming at the same speed on different courses
3. Both ships are steaming on the same course at different speeds
4. Both ships are steaming on the same course and at the same speed

10-2. Assume that your ship is steaming on course 180°T and a target is sighted at a range of 10 miles bearing 270°T. One hour later the range and bearing to the target is 5 miles at 270°T. What is the distance of relative movement?

1. 5 miles
2. 10 miles
3. 15 miles
4. 20 miles

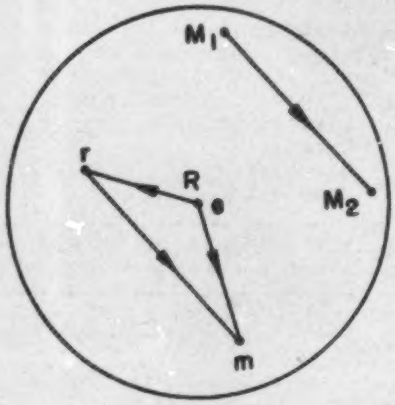

Figure 10A.--Relative movement plot

10-3. What symbol in figure 10A represents the position of the reference ship?

1. M_2
2. M
3. R
4. r

10-4. When is the position of the reference ship placed in the center of the maneuvering board?

1. Only when it is stationary
2. Only when it is a flagship or the command ship of formation
3. Only when its relative position to one other moving ship is being determined
4. At all times

10-5. What scale are you using if circle 7 on your maneuvering board represents 35,000 yards?
1. 2:1
2. 3:1
3. 4:1
4. 5:1

10-6. You are plotting a contact that will vary in range from 7,000 yards to 32,000 yards. You want to use one scale throughout the plot. Which scale do you use?
1. 1:1
2. 2:1
3. 3:1
4. 4:1

10-7. What does the length of line M_1-M_2 in figure 10A represent?
1. Actual speed of the reference ship
2. Relative speed of the maneuvering ship
3. Relative distance traveled by the reference ship
4. Relative distance traveled by the maneuvering ship

10-8. What does the line M_1-M_2 represent?
1. Actual course of the target
2. Actual course of own ship
3. Relative movement of the target
4. Relative movement of own ship

10-9. In figure 10A, the M_1-M_2 plot represents
1. speed and bearing
2. bearing and distance
3. distance and course
4. speed and course

● Plot the following information on a maneuvering board for items 10-10 through 10-11. You are on course 090° at 10 kts. At time 0305, you have a contact bearing 000°T at 9,200 yards. At time 0311, you hold the same contact bearing 040°T at 8,000 yards.

Learning Objective: Solve maneuvering board problems.

10-10. The DRM of the contact is
1. 031°T
2. 121°T
3. 162°T
4. 301°T

10-11. The SRM of the contact is
1. 3 knots
2. 30 knots
3. 60 knots
4. 70 knots

10-12. What approximate time in minutes does it take your ship to go 35,000 yards at a speed of 19 knots?
1. 55
2. 50
3. 45
4. 40

10-13. The vector diagram is used to indicate
1. speeds and bearings
2. bearings and distances
3. distances and courses
4. speeds and courses

10-14. In the vector diagram the length of line rm represents the
1. relative speed of the reference ship
2. relative speed of the maneuvering ship
3. actual speed of the reference ship
4. actual speed of the maneuvering ship

● Use the following information for items 10-15 through 10-21. Your ship is making 27 knots on course 033°T. At 1400 a contact bears 340°T at a distance of 19,000 yards. The same contact bears 325°T. distance 12,000 yards at 1406.

10-15. What is the direction of relative motion?
1. 175°T
2. 183°T
3. 225°T
4. 355°T

10-16. What will the contact bear from you when it reaches the closest point of approach (CPA)?
1. 033°T
2. 145°T
3. 183°T
4. 273°T

10-17. What will be the range to the contact when it reaches CPA?
1. 7,400 yards
2. 9,500 yards
3. 12,000 yards
4. 19,000 yards

10-18. What will be the contact's relative bearing from your ship when it reaches CPA?
1. 030°R
2. 183°R
3. 240°R
4. 273°R

10-19. What is the relative speed?
1. 20 knots
2. 30 knots
3. 40 knots
4. 50 knots

10-20. What will be the time when the contact reaches CPA?
1. 1406
2. 1413
3. 1419
4. 1440

10-21. What is the contact's course and speed?
1. 145°T at 21 knots
2. 183°T at 25 knots
3. 213°T at 25 knots
4. 324°T at 22 knots

● For items 10-22 and 10-23, assume that at 1406 the contact in the preceding problem changes course to 120°T and increases speed to 30 kts.

10-22. What will be the new bearing and distance of CPA?
1. 120°T, 15,000 yards
2. 164°T, 11,300 yards
3. 254°T, 4,000 yards
4. 273°T, 7,400 yards

10-23. What will be the new time of CPA?
1. 1406
2. 1414
3. 1419
4. 1423

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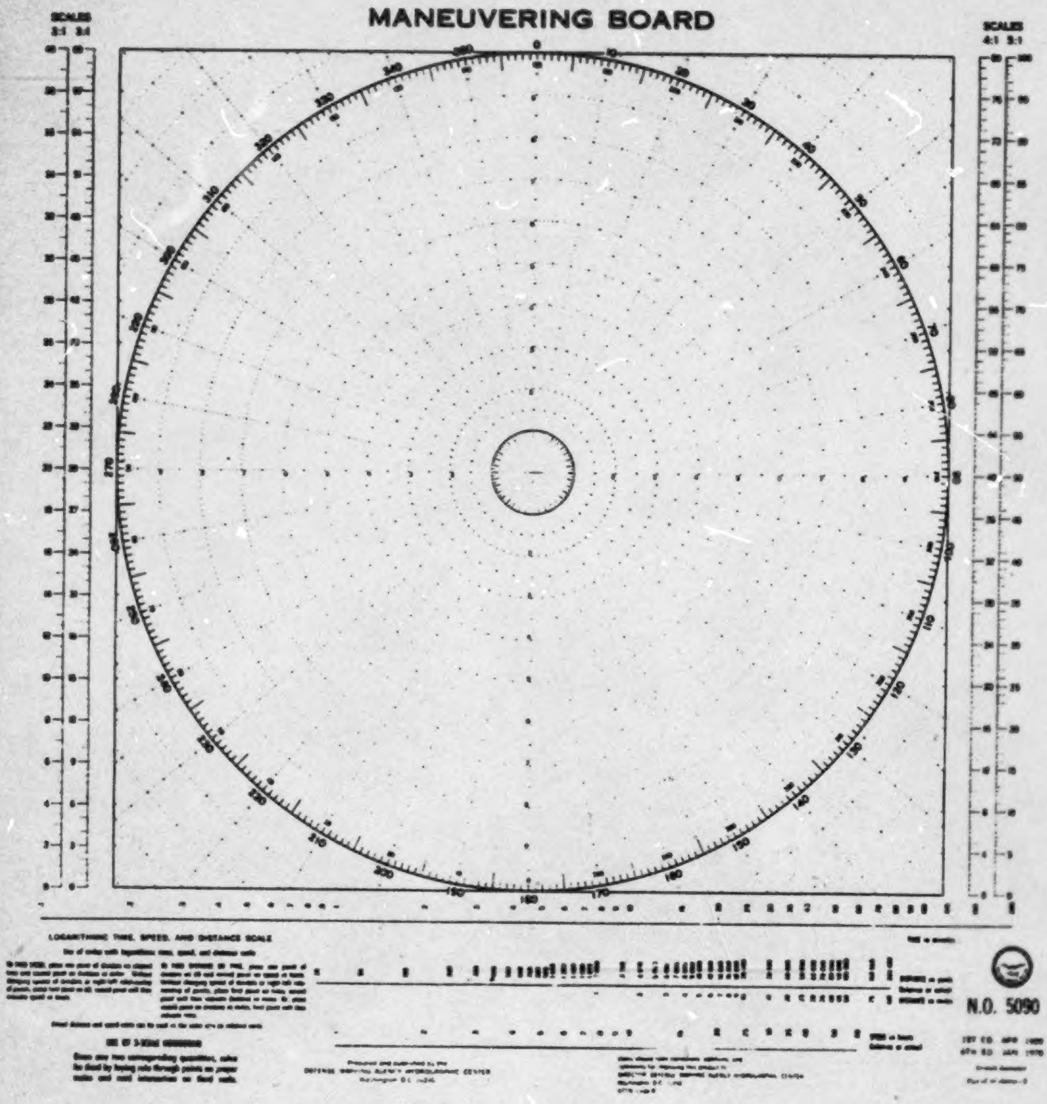
MANEUVERING BOARD
SCALES 2:1 3:1
SCALES 4:1 5:1
LOGARITHMIC TIME, SPEED, AND DISTANCE SCALE
N.O. 5090

Figure 10B.--Maneuvering Board

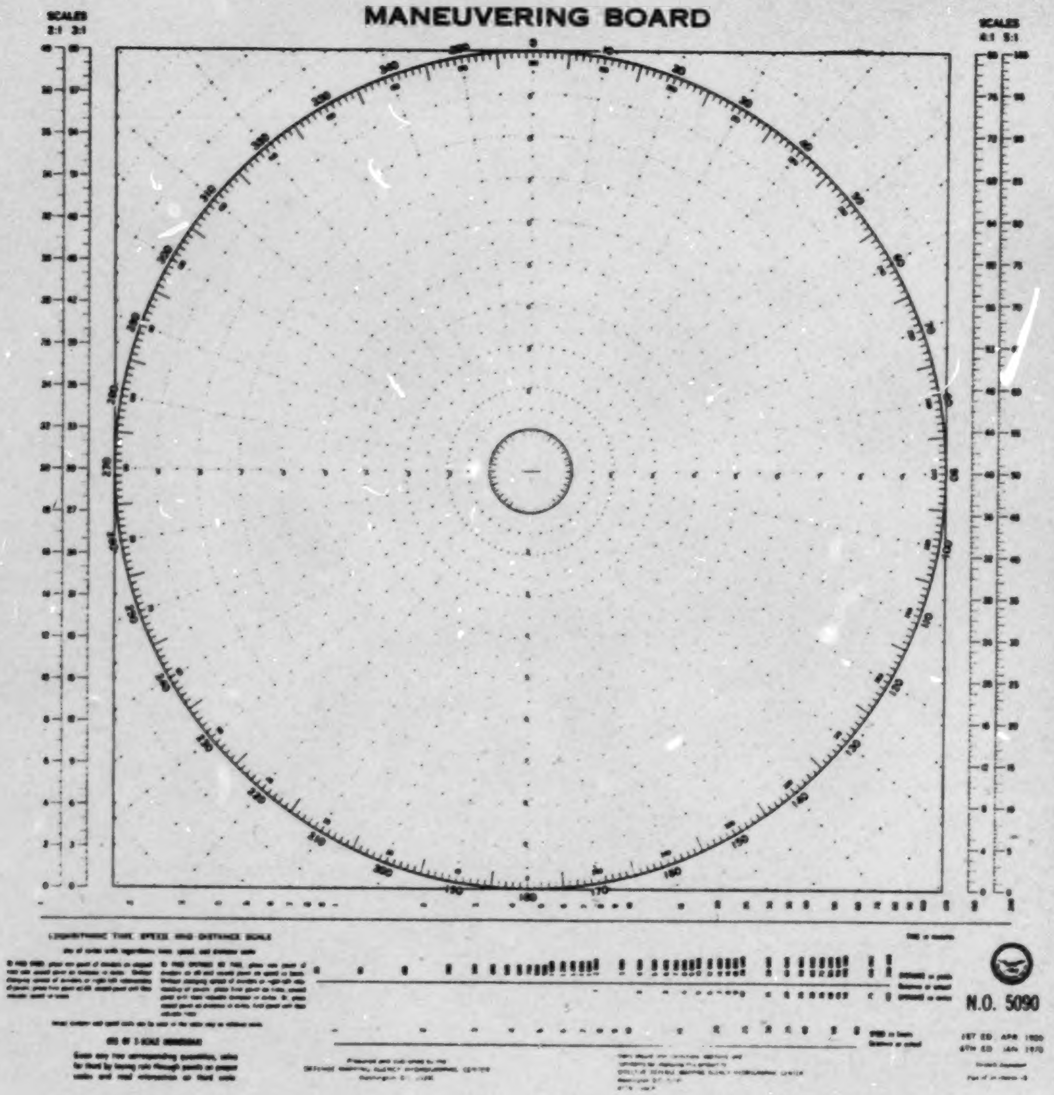
MANEUVERING BOARD
SCALES 2:1 3:1
SCALES 4:1 5:1
LOGARITHMIC TIME, SPEED AND DISTANCE SCALE
N.O. 5090

Figure 10C.--Maneuvering Board

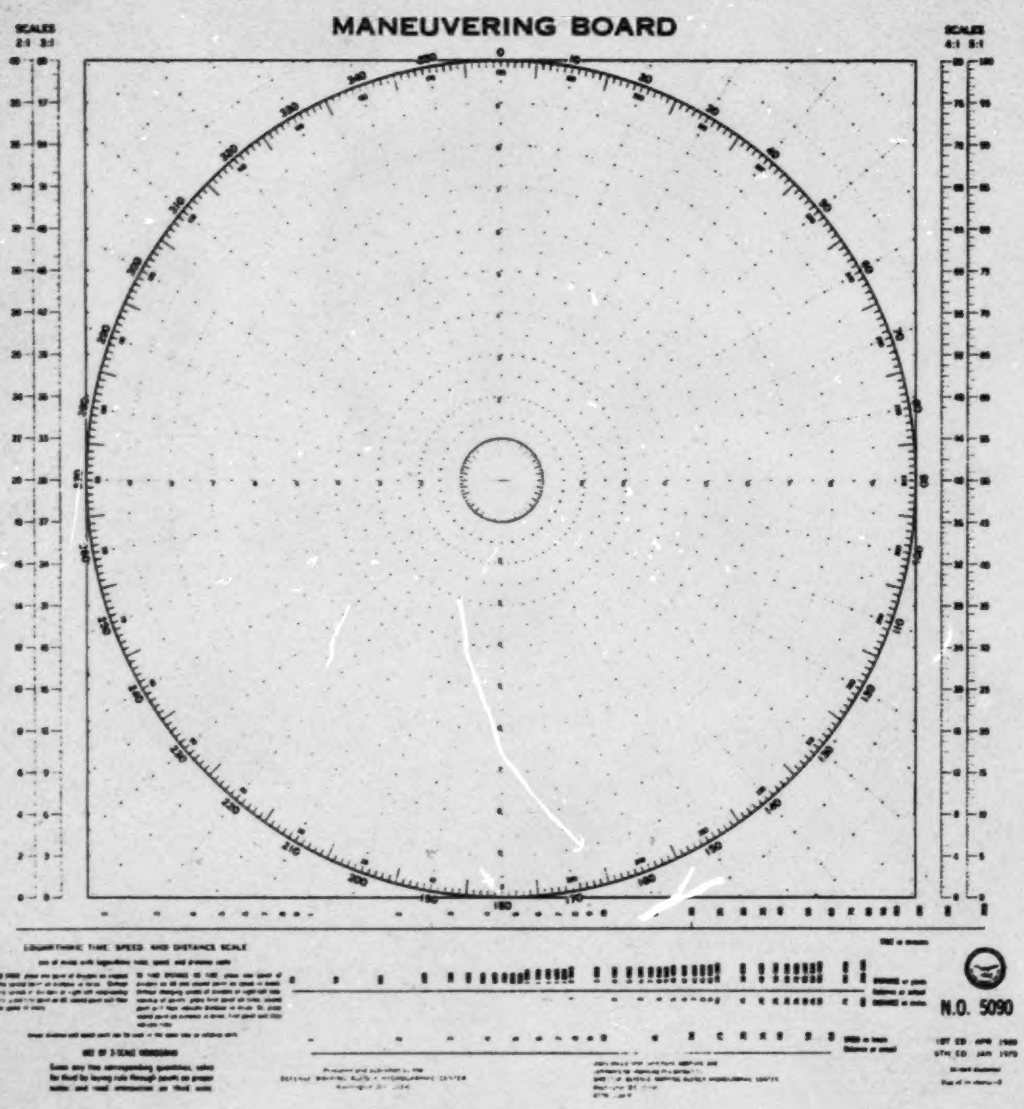
MANEUVERING BOARD
SCALES 2:1 3:1
SCALES 4:1 5:1
LOGARITHMIC TIME, SPEED, AND DISTANCE SCALE
N.O. 5090

Figure 10D.--Maneuvering Board

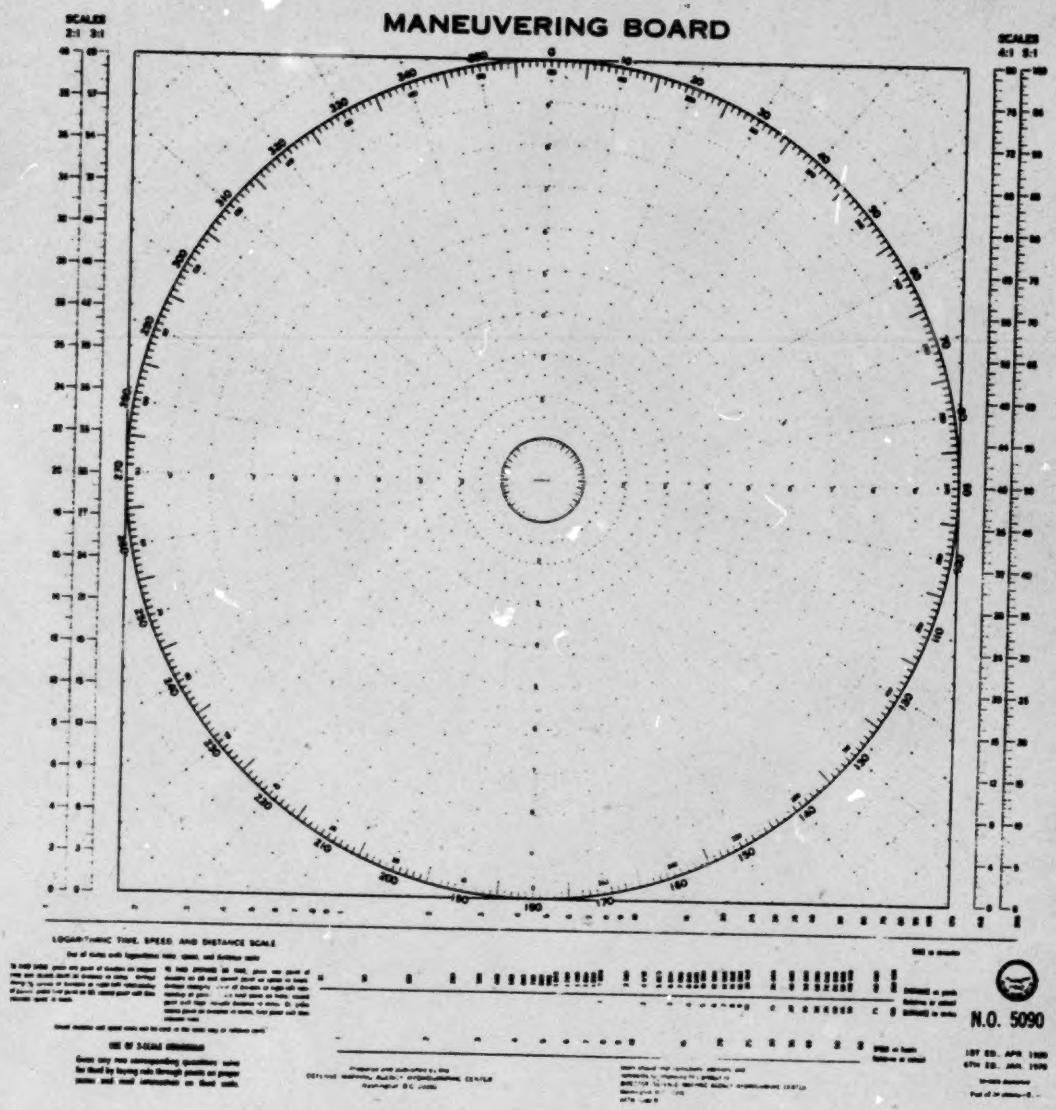
MANEUVERING BOARD
SCALES
2:1 3:1
SCALES
4:1 5:1
LOGARITHMIC TIME, SPEED, AND DISTANCE SCALE
N.O. 5090

Figure 10E.--Maneuvering Board

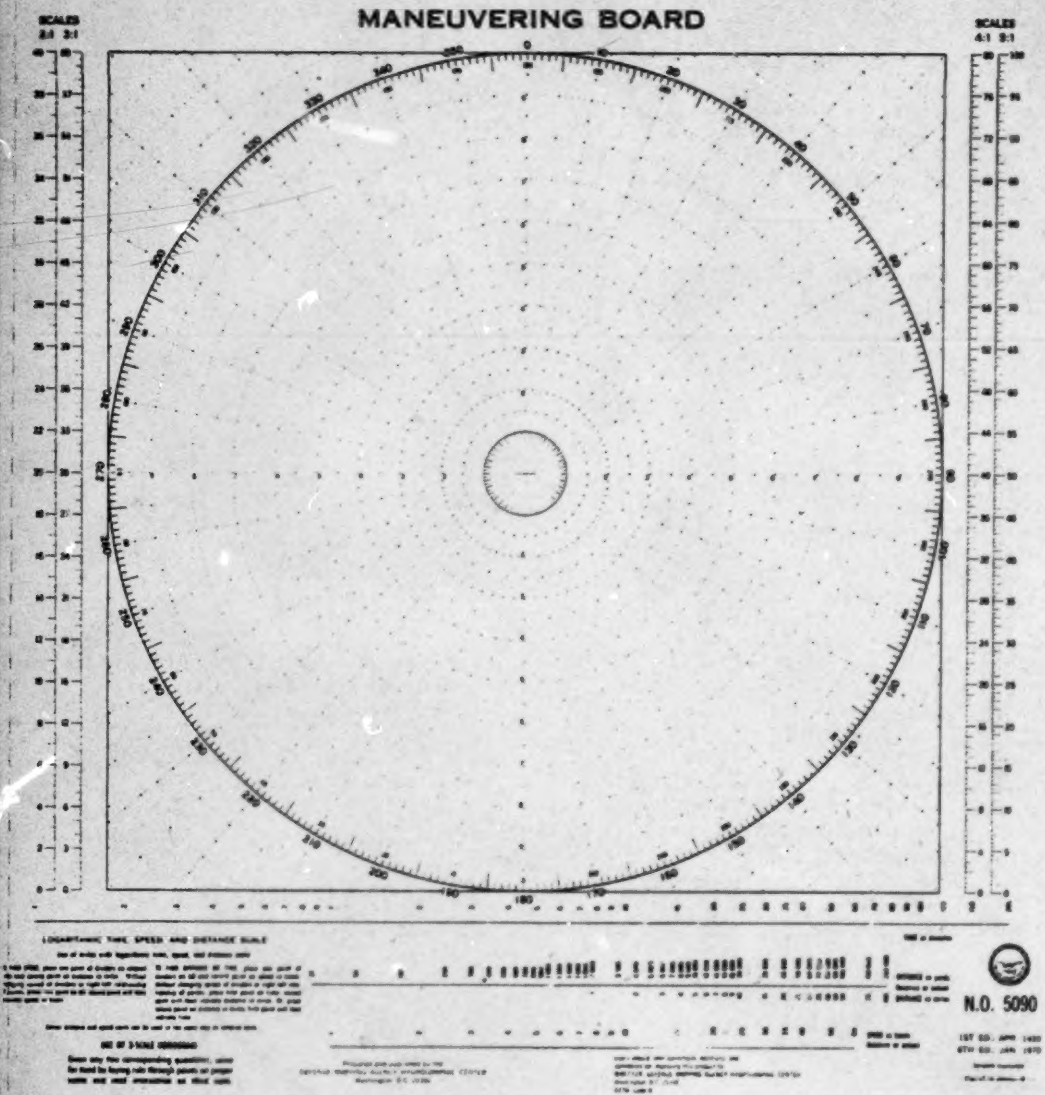
MANEUVERING BOARD
SCALES
2:1 3:1
SCALES
4:1 5:1
LOGARITHMIC TIME, SPEED, AND DISTANCE SCALE
N.O. 5090

Figure 10F.--Maneuvering Board

● Plot the following information on a maneuvering board for items 10-24 through 10-28. Assume that your ship is in formation steaming on course 130°T, speed 18 knots, with your ship at 200°T, 8 miles from the flagship. You receive orders to proceed at 25 knots to a new station bearing 090°T, distance 4 miles from the flagship. You are to use a course of 070°T.

10-24. What does the guide bear from you at the beginning of this maneuver?
1. 020°T
2. 090°T
3. 200°T
4. 270°T

10-25. What is the relative distance traveled by the maneuvering ship?
1. 10.1 miles
2. 12.8 miles
3. 14.6 miles
4. 18.2 miles

10-26. What is the bearing and range to the guide when you reach the closest point of approach (CPA)?
1. 020°T, 8 miles
2. 130°T, 3 miles
3. 270°T, 4 miles
4. 310°T, 3 miles

10-27. What course would you have to steer if you were required to proceed to station at 15 knots?
1. 070°T
2. 095°T
3. 125°T
4. 180°T

10-28 What speed would you have to make to station if you were required to steer a course of 130°T?
1. 12 knots
2. 15 knots
3. 18 knots
4. 25 knots

● Information for items 10-29 through 10-33. Your ship is the formation guide on course 175°T, speed 15 knots. Cruiser A bears 000°R from your ship, distance 10 miles, and is ordered to take station bearing 90°R from the guide, distance 7 miles. Cruiser A is to complete the maneuver in 50 minutes.

10-29. What is the direction of relative movement of Cruiser A?
1. 140°T
2. 320°T
3. 355°T
4. 000°T

10-30. What is Cruiser A's relative speed for this maneuver?
1. 9 knots
2. 10 knots
3. 15 knots
4. 30 knots

10-31. What course would Cruiser A steer to complete the maneuver?
1. 160°T
2. 175°T
3. 247°T
4. 282°T

10-32. What true speed will Cruiser A use for this maneuver?
1. 9 knots
2. 10 knots
3. 14.6 knots
4. 28.5 knots

10-33. What is Cruiser A's distance from your ship at CPA?
1. 2.9 miles
2. 5.7 miles
3. 7 miles
4. 10 miles

Learning Objective: Solve for apparent and true wind.

10-34. Your ship is on course 320°T, speed 15 knots and the relative anemometer shows 045° at 25 knots. What is the true wind?
1. 005°T at 25 knots
2. 042°T at 18 knots
3. 185°T at 25 knots
4. 222°T at 18 knots

10-35. Your carrier is on course 350°T, speed 15 knots. The true wind is 10 knots from 240°T. What is the apparent wind?
1. 060°T at 10 knots
2. 131°T at 15 knots
3. 170°T at 15 knots
4. 311°T at 15 knots

Learning Objectives: Identify various forms of naval communications, message forms, and formats. Define prowords.

10-36. What is the most secure method for a ship's external communications?
1. Voice radio
2. Visual
3. Messenger
4. Approved wire circuit

10-37. For fast, short range, external communications, ships use
1. messengers
2. registered mail
3. radiotelegraph
4. voice radio

10-38. What is the least secure method for a ship's external communications?
1. Voice radio
2. Visual
3. Messenger
4. Approved wire circuit

10-39. The correct distance between the lips and the radiotelephone microphone is about
1. 1 in.
2. 2 in.
3. 3 in.
4. 4 in.

10-40. What publication contains radiotelephone procedures?
1. Pub No. 102
2. ATP 1B
3. ACP 125
4. ACP 129

10-41. What is the correct pronunciation for the numeral 2,500?
1. Twen-ty fi-yive hun-dred
2. Too fife hun-dred
3. Too fife zero zero
4. Twen-ty fi-yive zero zero

Learning Objective: Define and interpret prosigns and prowords.

10-42. Why are prowords and prosigns used in naval communications?
1. To give a degree of security
2. To provide standard terminology
3. To speed the handling of messages
4. To confuse the enemy

10-43. What proword do you use to separate the heading of your message from the text?
1. BREAK
2. SEPARATION
3. PAUSE
4. WAIT

10-44. What is the corresponding prosign for the proword "Immediate Execute"?
1. XCT
2. XMT
3. $\overline{\text{XI}}$
4. $\overline{\text{IX}}$

10-45. What is the meaning of the prosign $\overline{\text{IMI}}$?
1. Execute
2. End of transmission
3. Repeat
4. Go ahead

10-46. What is the proword for an action addressee on a message?
1. ACTION
2. FROM
3. A
4. TO

Learning Objective: Identify forms and components of naval messages.

10-47. What are the three forms of military messages?
1. Heading, text, and ending
2. Preamble, address, and prefix
3. Voice radio, telegraph and visual
4. Plaindress, abbreviated plaindress, and codress

10-48. What is the most common message form used in voice radio communications?
1. Plaindress
2. Abbreviated plaindress
3. Codress
4. Executive

10-49. What are the three major parts of a message?
1. Heading, text, and ending
2. Preamble, address, and prefix
3. Plaindress, abbreviated plaindress, and codress
4. Procedure, preamble, and ending

Learning Objective: Determine proper radiotelephone procedures.

10-50. The text of a message contains a group of difficult words. In the message, you should preface this group of words with the proword
1. I SAY
2. I SPELL
3. INFO
4. SERVICE

10-51. What does the proword OUT mean?
1. The station sending the message wants the receiving station to acknowledge receipt of the message
2. The station sending the message is standing by for a reply
3. The station receiving the message is required to read it back to the sending station
4. The station sending the message has completed his transmission and requires no answer

● Information for items 10-52 thru 10-60: Your station is OLYMPUS and the collective call sign is EARTHBOUND. The stations in the net are WIND, FIRE, WATER, and AIR.

10-52. You call the stations on the net in order to check their transmission by sending
1. WIND, FIRE, WATER, and AIR--THIS IS OLYMPUS--OVER
2. EARTHBOUND--THIS IS OLYMPUS--OVER AND OUT
3. OLYMPUS--CALLING COLLECTIVE--OVER
4. EARTHBOUND--THIS IS OLYMPUS--OVER

10-53. You want to address a call to all net stations except FIRE. What should you transmit?
1. WATER--AIR--WIND--THIS IS OLYMPUS--OVER
2. EARTHBOUND--EXEMPT FIRE--THIS IS OLYMPUS--OVER
3. EARTHBOUND--THIS IS OLYMPUS--EXEMPT FIRE--OVER
4. EARTHBOUND--THIS IS OLYMPUS--FIRE DISREGARD--OVER

10-54. If communication conditions are good, which of the net stations will reply to your message first?
1. WIND
2. FIRE
3. WATER
4. AIR

● Information for items 10-55 and 10-56: You are next given a message for WIND and FIRE and you use the full message format. The date of the transmission is 30 June. The time is 1145 GMT. The text of the message is as follows: UNCLAS CONVOY ARRIVING THREE ZERO ONE FOUR THREE ZERO ZULU.

10-55. FIRE was unable to receive the heading of your message clearly because of static during transmission. In order to check the heading, FIRE transmits
1. OLYMPUS--THIS IS FIRE--SAY AGAIN--ALL BEFORE UNCLAS--OVER
2. OLYMPUS--THIS IS FIRE--REPEAT HEADING--OVER
3. THIS IS FIRE--REPEAT ALL BETWEEN FIRE AND CONVOY--OVER
4. THIS IS FIRE--REPEAT ALL BEFORE ZULU--OVER

10-56. During transmission of the text of your message, you accidentally send FOUR ZERO ONE FOUR. You do not notice the error until you have finished transmitting the text. At that point you correct the error by transmitting
1. THREE
2. CORRECTION--THREE
3. CORRECTION--ARRIVING THREE ZERO ONE FOUR
4. FOUR WRONG--CORRECTION THREE

10-57. To cancel your message during transmission, you have to send
1. DISREGARD THIS TRANSMISSION
2. another message to cancel the first
3. the word CANCEL
4. the proword ERROR repeated three times

10-58. When transmitting a message, to which no reply is permitted, you repeat
1. each group immediately after it is sent
2. the entire message
3. the text of the message only
4. the heading of the message only

10-59. FIRE wants verification of a message sent by OLYMPUS; OLYMPUS should retransmit the
1. entire message immediately
2. entire message after checking it with the originator
3. heading of the message
4. text of the message after checking it with the originator

10-60. WATER reads back a message incorrectly. You answer with the proword WRONG followed by the
1. DTG of the message
2. proword CORRECT MESSAGE IS
3. correct version of the message
4. call sign of the station called

10-61. The executive method of radiotelephone transmission is used to
1. ensure that stations called act in a timed sequence
2. permit deferred action by the stations called
3. permit several stations to act simultaneously
4. notify the stations called that the message takes priority over all others

10-62. What proword immediately precedes the proword ordering units to execute a tactical signal?
1. Execute to follow
2. Immediate execute
3. Standby
4. Execute

10-63. You receive a tactical message in which the text is repeated twice. What executive method is being used?
1. Intermediate
2. Normal
3. Delayed
4. Immediate

10-64. Who is authorized to acknowledge a message?
1. The operator responsible for transmitting the original message
2. The originator of the original message
3. Anyone authorized by the originator of the original message
4. The commanding officer or persons authorized by him

10-65. You have been directed by proper authority to acknowledge a message over the radiotelephone. You reply with the proword(s)
1. ROGER only
2. WILCO only
3. ROGER WILCO
4. ACKNOWLEDGE

Assignment 11

Communications (Continued)

Textbook, NAVEDTRA 10149-F: Pages 268-283

Learning Objective: Identify methods of visual signaling.

11-1. Your best approach to learning the Morse code visual equivalents of characters is to
1. count the dots and dashes
2. learn the sight patterns
3. count the numbers of combinations of dots and dashes
4. learn the rhythmic patterns of dots

Group	Code	Phonetic Spelling
DXT		DELTA XRAY TANGO
	·−· −·−− −·−	
GNM		GOLF NOVEMBER MIKE

Table 11A

● Table 11A shows code groups, Morse code characters, and phonetic spellings. Fill in the blank spaces in the table before answering exercises 11-2 through 11-4.

11-2. What Morse code characters should be placed in the code column for the group DXT?
1. ··− −··− ··
2. −·· −··− ··
3. −−· −·−· −
4. −·· −··− −

11-3. What is the phonetic spelling for the Morse code group shown under "Code"?
1. KILO QUEBEC ROMEO
2. KILO YANKEE ROMEO
3. ROMEO YANKEE KILO
4. ROMEO QUEBEC KILO

11-4. What are the Morse code characters for the phonetic spelling GOLF NOVEMBER MIKE?
1. ·−− ·− ··
2. −−· −· −−
3. ·−− −· −
4. −−· ·− −−

11-5. The next to the last character in the word INTERROGATIVE is pronounced
1. $\underline{\text{VEEK}}$ TOR
2. $\underline{\text{VEEK}}$ TOH
3. $\underline{\text{VIK}}$ TAH
4. VIK $\underline{\text{TAH}}$

Learning Objective: Identify techniques of learning and transmitting Morse code and semaphore signals

11-6. What is the sight pattern for the number zero?
1. Dot-dash-dash-dash-dash
2. Dot-dot-dash-dash-dash
3. Dot-dot-dot-dot-dot
4. Dash-dash-dash-dash-dash

11-7. When you first practice receiving Morse code, you should start by learning to read
1. individual dots and dashes
2. individual letters and numbers
3. code groups
4. plain language

11-8. At what rate should you first practice sending Morse code by flashing light?
1. Fastest possible
2. Slowest practicable
3. Half that at which you can receive
4. The same as that at which you can receive

11-9. Compared with flashing light, semaphore provides greater
1. speed and range
2. speed and security
3. security and range
4. security, range, and speed

11-10. Which method of visual signaling requires no special equipment for short distances?
1. Yardarm blinker
2. Flashing light
3. Flaghoist
4. Semaphore

11-11. When you send semaphore, you should make sure that you
1. position your arms correctly
2. move your flags smartly
3. do not confuse your right arm position with the left arm position
4. do all of the above

11-12. How many letters may be transmitted using a single flag?
1. 4
2. 7
3. 8
4. 14

11-13. How many combinations of the arm position are possible in semaphore?
1. 4
2. 8
3. 26
4. 28

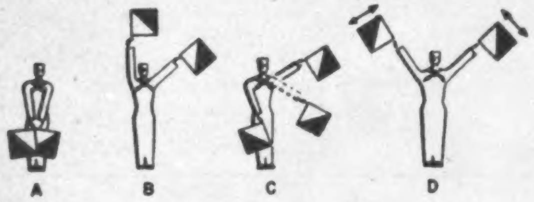

Figure 11A.--Semaphore flags

Items 11-14 thru 11-16 refer to figure 11A.

11-14. Semaphore signal A is used to
1. indicate an error
2. separate code groups
3. attract attention
4. answer a call

11-15. What signal do you use just before you transmit a sequence of numbers?
1. A
2. B
3. C
4. D

11-16. Signal D is used to
1. indicate an error
2. indicate the end of a word
3. attract attention
4. answer a call

11-17. One of the most popular methods of teaching strikers the semaphore alphabet is known as the system of
1. pairs
2. opposites
3. wholes
4. repeaters

Learning Objective: Identify signal flags and flaghoist procedure.

11-18. Which method of visual signaling generally ensures a more uniform execution of a maneuver than any other system?
1. Flaghoist
2. Semaphore
3. Flashing light
4. Pyrotechnics

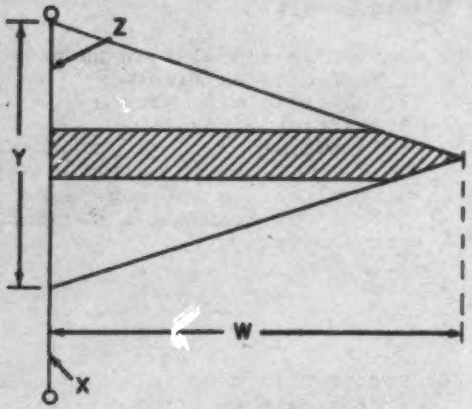

Figure 11B.--Signal flag

- Items 11-19 thru 11-21 refer to figure 11B.

11-19. The fly of a signal flag is indicated by the letter
1. W
2. X
3. Y
4. Z

11-20. What part of a flag is shown by the letter Y?
1. Tackling
2. Hoist
3. Tabling
4. Tail line

11-21. What is the function of part X?
1. To space flags in a signal
2. To reinforce the flag at the point of greatest stress
3. To hoist the flag to the yardarm
4. To attach the flag to the preceding flag

11-22. A group of flaghoist signals flying simultaneously is called a
1. fly
2. display
3. hoist
4. simultaneous hoist

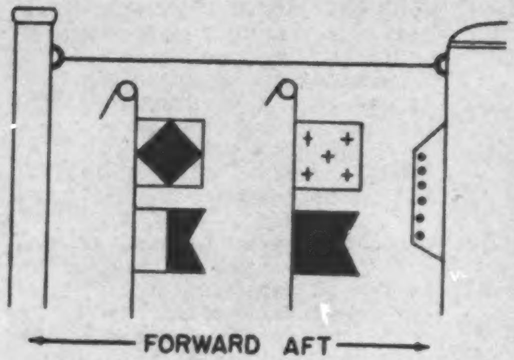

Figure 11C.--Flaghoist signals

- Items 11-23 and 11-24 refer to figure 11C.

11-23. The flaghoist signal is flown from the
1. truck
2. triatic stay
3. port yardarm
4. foremast

11-24. What is the complete signal (in proper order)?
1. FOXTROT, ALFA, ZERO, BRAVO
2. BRAVO, ZERO, ALFA, FOXTROT
3. FOXTROT, ZERO, ALFA, BRAVO
4. ZERO, BRAVO, FOXTROT, ALFA

11-25. Assume that a ship raises several flaghoist signals, one hoist at the masthead, one hoist at the port yardarm, and three hoists at the starboard yardarm. In what order do you read the display?
1. Masthead, port yardarm, starboard yardarm outboard in inboard
2. Starboard yardarm inboard to to outboard, port yardarm, masthead
3. Port yardarm, starboard yardarm outboard to inboard, masthead
4. Masthead, starboard yardarm outboard to inboard, port yardarm

11-26. Your ship is addressed by flaghoist from a merchant ship. You indicate that the signal is understood by hoisting the
1. same signal flags and holding them at the dip
2. ANSWER pennant and closing it up
3. ANSWER pennant and holding it at the dip
4. INT flag and closing it up

11-27. Assume you are addressed by flaghoist from another U.S. Navy ship. What signal do you hoist to let the other ship know that the signal is not understood?
1. Hoist the same signal at the dip and hoist the interrogative pennant close up
2. Hoist the same signal close up
3. Hoist the interrogative pennant and at the dip
4. Hoist the same signal close up and hoist the interrogative pennant at the dip

11-28. To indicate that a flaghoist signal group is from Pub No. 102, you first hoist
1. VB
2. INT
3. CODE
4. DESIG

11-29. What is the proper use of substitutes in hoisting the flaghoist signal DELTA BRAVO TACK BRAVO DELTA BRAVO?
1. D B TACK 1st 2nd 3rd
2. D B TACK 2nd 1st 2nd
3. D B TACK 2nd 1st 3rd
4. D B TACK 2nd 1st 4th

● Items 11-30 thru 11-34 refer to figure 11D.

11-30. Which illustrations represent letters of the alphabet?
1. A and C
2. B and H
3. B and E
4. D and G

11-31. One of the substitute pennants is shown in part
1. C
2. D
3. E
4. F

11-32. Which illustrations are examples of special flags and pennants?
1. B and C
2. A and C
3. E and F
4. F and G

11-33. The numeral pennants are labeled
1. A and C
2. A and F
3. C and F
4. A, C, and D

11-34. You are recording flaghoist signals in a log. How do you record the signals labeled B, A, G, and H?
1. Rp7 SPEED THREE
2. ROMEO 7 3rd 3
3. Rp7 S 3
4. Rp7 SPEED 3

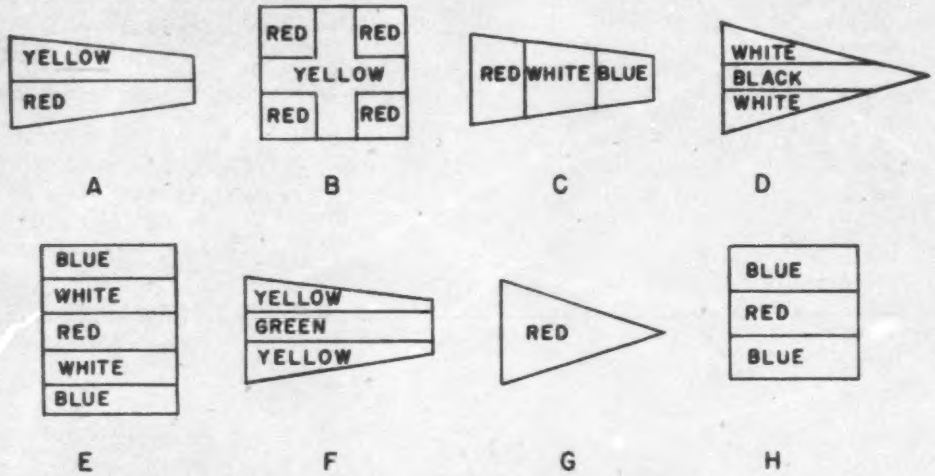

Figure 11D.--Flags, pennants, special flags and pennants, and substitutes

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Learning Objective: Recognize visual communications procedures.

11-35. What publication contains visual communication procedures?
1. ACP 125
2. ATP 1B Vol I
3. JANAP 119
4. ACP 129

11-36. You are about to transmit the prosign $\overline{IMI}$ by flashing light. The overscore tells you to
1. pause for 5 seconds between letters
2. transmit as a single character without pausing
3. transmit the meaning of the prosign, i.e., repeat
4. send the word CODE before transmitting the prosign

11-37. What is the answer prosign used in semaphore?
1. R
2. C
3. U
4. $\overline{AR}$

11-38. What is the meaning of the prosign L in a message sent by flashing light?
1. Exempted call sign follows
2. Call sign follows
3. Unknown station
4. Relay

11-39. What is the semaphore equivalent for a hyphen?
1. -....-
2. $\overline{DU}$
3. -
4. $\overline{XE}$

11-40. Operating signals are three letter signals that always begin with the letters
1. B or Q
2. Q or Z
3. X or Y
4. Y or Z

11-41. All operating signals used by non-military activities begin with the letter
1. Q
2. X
3. Y
4. Z

11-42. QRS is the operating signal which means, send more slowly. How do you, on board a ship whose call sign is NDHY, ask another U.S. Navy ship, call sign NFCH, if you should signal more slowly?
1. NFCH DE NDHY $\overline{IMI}$ QRS K
2. NFCH DE NDGY $\overline{INT}$ QRS K
3. NFCH DE NDHY QRS $\overline{IMI}$ K
4. NFCH DE NDHY QRS $\overline{INT}$ K

11-43. Which of the following call signs is an example of an international call sign?
1. D p3 p5
2. NHWZ
3. AA
4. 1 p7 p7

11-44. What publication contains allied address groups?
1. ACP 100
2. ACP 119
3. ACP 121
4. ACP 131

In items 11-45 thru 11-50, select the message component from column B that includes the visual message element in column A.

A. Elements

11-45. The ship sending the message

11-46. The message group count

11-47. The date-time group

11-48. The originator

11-49. Relay instructions

11-50. The accounting symbol

B. Components

1. Procedure
2. Preamble
3. Address
4. Prefix

11-51. The message components listed in column B above are part of a message's
1. heading
2. text
3. ending
4. transmission instructions

11-52. What ending prosign is used in a message to a merchant ship?
1. $\overline{\text{AS}}$
2. $\overline{\text{AR}}$
3. K
4. $\overline{\text{IMI}}$

Learning Objective: Identify sound signals.

11-53. You hear the ship's bell ring rapidly and then two distinct strokes. This tells you that there is a
1. man overboard, port side
2. man overboard, starboard side
3. fire, forward
4. fire, amidships

● Item 11-54 is either True or False.

11-54. The continuous sounding of any fog signal apparatus is a signal of distress.

11-55. How many short blasts does a ship sound when hoisting an emergency signal to attract the attention of other ships in the vicinity?
1. 4 short blasts
2. 5 short blasts
3. 6 short blasts
4. 7 short blasts

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